ENGINEERING NEWS
AND
AMERICAN RAILWAY JOURNAL.

VOL. XLI. No. 26.

TABLE OF CONTENTS.

ENGINEERING NEWS OF THE WEEK 405
Some Notable Australian Steel Pipe Lines (illustrated) 406
Early Engineering Work in the United States.... 407
Best Method of Applying Stay Bolts to Locomotive Boilers (illustrated) 410
Recent Practice in Purifying Feed Water for Locomotives (illustrated) 411
Annual Convention of the American Railway Master Mechanics' Association 413
The Preservation of Railway Ties by Zinc Chloride. 414
Annual Convention of the British Association of Water-Works Engineers 419
Legal Decisions of Interest to Engineers.......... 419
The Biennial Conference of the Institution of Civil Engineers 421
EDITORIAL NOTES 416
The Biennial Conference of the Institution of Civil Engineers of Great Britain—The Drouth and Water Waste.
EDITORIAL:
The Partial Abolition of Water Rates at Detroit.. 416
LETTERS TO THE EDITOR 417
Concerning Fuel Saving Devices in Steam Plants—Random Notes Abroad—Notes and Queries.

BIDS FOR THE WATER-POWER PRIVILEGES of the Chicago Drainage Canal are to be invited, and will be advertised for, according to a recent decision of the Drainage Board. A proposition has been made by Mr. Clarence Buckingham, reported as representing the Diamond Match Co. He wanted a lease for 50 years, and offered to pay a rental of $5 per HP. per year, with a rebate of $2.50 to the company to reimburse it for the cost of its investment in plant. Mr. John L. Norton, of the Economic Light & Power Co., of Joliet, followed this by an informal proposition to develop the water power at Hickory Creek and Lockport, and to pay $6 per HP. per year. At the meeting of the Drainage Board on June 21, Mr. Eckhart, one of the Trustees, stated that an offer of $5 per year was ridiculously low, the privilege being worth at least $20 per HP. per year. He thought the Board should develop the power itself, and have the profits, instead of turning the matter over to private parties. The city of Chicago could utilize the power to advantage. He objected to leasing the water power to such parties, and thought that if the power is to be leased, the matter should be first given the widest publicity. Eventually the Board decided to advertise for bids for the development and leasing of the water power along the main drainage channel and its auxiliary channels. All propositions are to include the development of power at Lockport and Hickory Creek. It is estimated that at the latter point, 7,000 HP. can be developed from a flow of 300,000 cu. ft. of water per minute at a cost of less than $200,000. Any disposition the Board may wish to make in regard to the water power must, under the law, be arranged before the channel is opened. The conditions of water-power development, as stated by the Chief Engineer, Mr. Isham Randolph, were described in our issue of Feb. 23, 1899.

◆

ANALYSES OF THE WATER along the Illinois River are to be made as a preliminary to the study of the effect which the opening of the Chicago Drainage Canal will have upon the quality of water in the river. The Drainage Board has already planned such an investigation, but an entirely independent investigation will be made under the direction of the State Board of Health. The work will be in the hands of Prof. John W. Long, of Northwestern University, and Mr. Jacob A. Harman, M. Am. Soc. C. E., of Peoria, Ill. Observing stations will be located and samples of water collected at numerous points along the river. The Board has designated certain of these points as follows:

Hydrants in Chicago; Bridgeport, before the water has passed the pumps; Lockport, Joliet, Morris, Ottawa, La Salle, Henry, above the dam; Peoria, above lake; Pekin, above city; Pekin, below the distilleries; Havana, Pearl, Grafton. Mississippi River at points above and below the mouth of the Illinois River; Desplaines River, at its junction with the Kankakee; the Kankakee at the same point; the Fox, Vermilion and Sangamon Rivers, where they meet the Illinois. The survey and examination will, it is believed, require a period of six months.

◆

AN AUTOMATIC GUARD-GATE FOR CANALS is described in the "Centralblatt der Bauverwaltung." This guard-gate is practically a box with double sides but no bottom, movable around a horizontal axis connected with one side of the box. By means of a three-way valve in a well in one abutment, the hollow sides of the box, through one of the hollow horizontal axes, are put in communication either with the air, or with the water in the canal, or with the lower level of the canal. If the water in the canal, by reason of some break in the bank, descends below a certain level, it lowers a float in the well and sets free a weight, which by falling operates the three-way valve and puts the inside of the box in communication with the water in the lower canal-level, and all the water in the box escapes into this lower level. The empty gate is now raised by the pressure of the water above, and under the action of the current developed it turns on its horizontal axis until it strikes certain vertical stops in the masonry. To lower the gate again, with the water at the same level on both sides, the valve is turned by a key so as to admit water to the inside of the box, when the box sinks to its normal position. Absolute contact with the sill is assured by a bolt, which is pulled out by the operation of the three-way valve.

◆

THE ISTHMIAN CANAL COMMISSION has been organized in the following committees appointed by the Chairman, Admiral Walker:

For the Investigation of the Nicaragua Route—Mr. Noble, Mr. Burr and Colonel Hains.

For the Investigation of the Panama Route—Mr. Burr, Mr. Morrison and Colonel Ernst.

For the Investigation of Other Possible Routes—Mr. Morrison, Mr. Noble and Colonel Hains.

For the Investigation of the industrial, commercial and military value of an interoceanic canal—Professor Johnson, Professor Haupt and Mr. Pasco.

For the Investigation of Rights, Privileges and Franchises—Mr. Pasco, Colonel Ernst and Professor Johnson.

It is stated that as soon as the preliminary work of the Commission is completed, the members will start for the Isthmus.

◆

A NEW METHOD OF JOINTING SEWER PIPE to secure greater tightness, is being used on some work at Steelton, Pa., by Mr. Alex. Potter, Assoc. M. Am. Soc. C. E., 137 Broadway, N. Y. The joints are calked with strips of burlap, previously dipped in hot asphalt and afterwards twisted. Mr. Potter states that experimental joints have withstood a pressure of 50 lbs. per sq. in., within 30 minutes of completion, without rupture. The use of this system is proposed on the joint outlet sewer for Newark, South and West Orange, Millburn and other municipalities.

◆

AN APPRAISEMENT OF THE WORKS of the Dubuque Water Co. is being made by a board of five members, including Mr. Benezette Williams, of Chicago, and Ex-Governor Horace Boies, chairman. The consulting engineer for the city is Mr. Charles C. Chace, of Iowa City, who has selected as experts on valuation Messrs. Samuel G. Artingstall and W. S. McHarg, of Chicago, and W. Kiersted, of Kansas City. The consulting engineer for the company is Mr. John W. Alvord, of Chicago, who has called in on valuation Messrs. John T. Fanning, of Minneapolis; John W. Hill, of Cincinnati; Geo. H. Benzenberg, of Milwaukee, and Daniel W. Mead, of Chicago. Prof. E. G. Smith, of Beloit, Wis., has also been retained as chemist in the interests of the company. A schedule of quantities has been agreed on, and the company has begun to present its side.

◆

THE SEWERAGE SYSTEM OF GALVESTON, TEX., is to be acquired by the city and extended. It was built some years ago by the Galveston Sewer Co. and has just been appraised at $93,600. A sewer bond issue of $300,000 was approved by popular vote some time ago, but its legality is now in the court.

◆

THE MOST SERIOUS RAILWAY ACCIDENT of the week occurred on the Pittsburg & Western R. R., on June 24, about 7 miles south of Butler, Pa. According to reports the accident happened to an excursion train which was running at a high rate of speed around a sharp curve when two passenger coaches jumped the track and rolled down a high embankment. It is further stated that the direct cause was a difference in level of the rails where the road crossed the Buffalo, Rochester & Pittsburg R. R. Eight persons were injured, two perhaps fatally.

◆

THE MORGAN LINE STEAMER, "EL RIO," was launched on June 24 at the yards of the Newport News Shipbuilding & Dry Dock Co., at Newport News, Va. The "El Rio" is a sister ship of "El Norte" and "El Sud," which were launched in April and are now nearly ready for service, and also of "El Cid," which is now being built, and will be ready for launching in a few weeks. Each of the vessels is designed for service between New York and New Orleans, and will cost $600,000. The dimensions of "El Rio" are as follows: length over all, 406 ft.; length between stem and propeller post, 380 ft. 8½ ins.; breadth, molded, 48 ft.; depth, molded to awning deck, 33 ft. 9 ins.; gross tonnage, 4,665 tons; net tonnage, 2,905 tons. The hull is of steel throughout, the outside plating having vertical lap joints below the water line. The vessel has three contiuuous decks and partial orlop deck at forward end of forehold. It is rigged with two steel masts and necessary booms for hauling cargo, together with steam hoisting engines located at the different hatches. The deckhouses are of steel, with round side lights. The ship is provided with steam steering gear at forward pilot house, and a screw hand gear at the after house. A flying bridge connects the forward house with the main house. Steam windlass and steam capstans are provided for handling anchors, hawsers, etc. The engines will be of the triple-expansion type, and steam will be generated by three double-ended boilers 13 ft. 10 ins. in diameter. The total heating surface is 10,650 ft., and the working steam pressure is 180 lbs.

◆

THE OSCILLATION OF SHIPS can be measured by a special gyroscopic device manufactured by MM. Guzzi, Ravizza & Co., of Milan, Italy, and known as the oscillometer. This instrument consists of a small electric motor mounted in gimbals, like a ship's compass, with its armature running in a vertical position at a very high rate of speed. As the ship rolls the armature maintains its original position, while the frame supporting the gimbal rings follow the motion of the ship. Suitable scales and pointers are provided, so that the amount of movement can be accurately determined. Another instrument, made by the same company and known as the gyroscopic compass, is constructed upon the same principle with a horizontal dial like the ordinary mariner's compass. The frame of this instrument, being attached to the vessel, follows any change in direction, while the motor armature continues to revolve always in the original plane. In this way any change in direction of the vessel is at once indicated.

◆

TWO LARGE SUCTION DREDGES are planned for the work on the new ship channel into New York harbor, for which Mr. Andrew Onderdonk, of New York, N. Y., has the contract, as noted in our issue of May 18. The dredges will have steel hulls, and the plans require that each shall have sufficient power to pump sand through tubes at the rate of 4,000 tons an hour. The hoppers of each vessel are to have a total capacity of 3,000 tons of wet sand. Each craft is to be equipped with twin screw engines, capable of making a speed of ten knots an hour. The measurements of the vessels are: length, 320 ft.; beam, 47 ft. 10 ins.; depth, 20 ft. 6 ins., and draft when loaded and equipped, 16 ft. 4 ins. For pumping the sand there are two centrifugal pumps, having 36-in. suction and delivery pipes, each worked by a triple-expansion engine. The pumps, placed on each side of the well, drew from a T-head at the top of the suction pipe. The T-head also serves as a trunnion or hinge, around which the tube can swing, so that it can be raised or lowered at will. Fitted to the suction tube, close to the T-head, is a ball and socket joint, which gives a motion sideways. The nozzle of the pipe has its aperture nearly at right angles to the axis of the tube, and is so arranged that nothing of sufficient size to choke the pumps can pass through it. Each centrifugal pump may be disconnected in case of accident and the other pump may be worked alone. By means of a hydraulic apparatus, the main suction tube is raised and lowered. This suction tube is also fastened by chains and other gear, by which it may be lifted in case of accident to the hydraulic apparatus.

◆

THE STREET RAILWAY QUESTIONS which will be discussed at the meeting of the International Tramways Union, at Paris, next year, are as follows:

1. Fares and average receipts per car mile on city lines.
2. The results of the introduction of electric traction in regard to the traffic, the operating expenses and the net benefits.
3. The advantages and disadvantages of narrow and standard gage for electric traction.
4. Central electric power plants, their equipment, and the cost of distributing the current.
5. Which is the best system of distribution for important roads, including suburban lines, the continuous, alternating or polyphase system?
6 The Falk cast-welded joint.
7. The progress made in electric traction on the storage battery system.
8. Methods of car heating for passenger and mixed trains on country lines.
9. The advantages and disadvantages of the operation of secondary or light railways by their owners or by the trunk lines for which they serve as feeders.

◆

ELECTRICITY FROM COAL MINES as power for the Paris Exhibition, has been proposed by Mr. John T. Bramhall. The object is partly to form an illustration of modern methods of utilizing electrical power by long-distance transmission, but mainly to avoid smoke and dirt at the exhibition, and to save space required for storing and handling the great supply of coal and the resulting ashes. His proposition was to establish a power plant at mines within 100 miles of the city, and he claimed that the results would probably lead to the permanent establishment of the plant, while if it did not, the copper or aluminum in the conductors would have a considerable selling value. At the Columbian Exhibition (Chicago) in 1893, oil fuel was pumped from the Ohio oil fields, and it is proposed to run the machinery at the coming Buffalo exhibition by electric power transmitted from the Niagara Falls plant.

SOME NOTABLE AUSTRALIAN STEEL PIPE LINES.

In our issue for June 9, 1898, we described a steel pipe line, with locking-bar joints, in place of longitudinal lap-riveting. The pipe forms a part of the water-works of Adelaide, Western Australia, and the article in question was prepared by Mr. Alex. B. Moncrieff, M. Inst. C. E., M. Am. Soc. C. E., Engineer-in-Chief of the Department of Public Works of Western Australia, who is located at Adelaide. In view of the adoption of this locking-bar system for the 328 miles of 30-in. steel main, composing the Coolgardie pipe line, we requested Mr. Moncrieff to give us further information regarding his experience with the joint in question. Accordingly, Mr. Moncrieff wrote, under date of March 1, as follows:

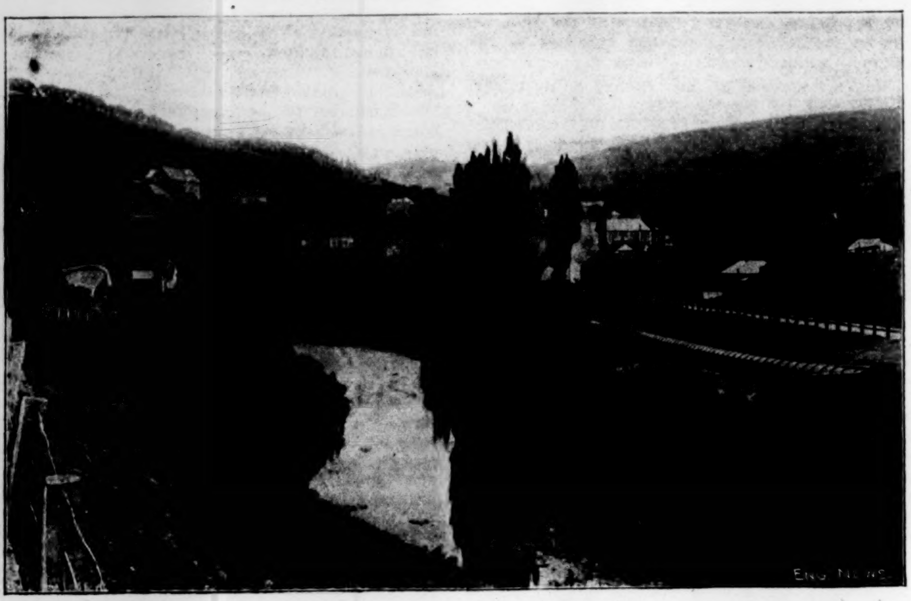


FIG. 6.—VIEW OF 6-FT. STEEL PIPE LINE, HAPPY VALLEY WATER-WORKS.

I have read with interest the article in your issue of Dec. 29, 1898, on the Coolgardie pipe line. In reply to your inquiry regarding my experience with the locking-bar joints, I have pleasure in informing you that neither in the making, testing, laying, nor in the use afterwards of the pipe which we recently laid down, have we had the slightest trouble. I have already furnished you with details of the construction of the pipe (Eng. News, June 9, 1898). In the laying we served it out in long lengths on the roadside, being careful in the discharging that the coating was not injured. We slung it into the trenches with broad leather bands, using two tripod cranes in the usual way. The pipes went into their places without difficulty, the joint rings were put into position and securely fastened with short lead wedges; clay luting was used, and the melted lead was poured in from two runners at the same time. When cold, this lead filling was trimmed and calked in the usual way. This style of construction lends itself to slight variations in grade and direction in exactly the same way as the ordinary cast-iron pipes will accommodate themselves in the spigots and faucets.

The connections for the branch pipes were of cast iron and riveted on to the plates, this having been arranged for on the drawing and the work carried out before the pipes came on the ground. In the final testing we shut off the branch mains, putting on the whole head of pressure and leaving it for 24 hours. The measurement of the leakage was made at the pipe-head tank, and proved to be practically nil.

In any places where the coating had received slight damage in the handling the pipe was slightly warmed and a fresh supply of the coating material was brushed over it, being afterwards dusted with sand. A portion of the pipe-line was through salt ground; in such positions I removed a larger quantity of the natural earth than usual and filled in round the pipe with sand, as this arrangement has in other places proved effective.

That the pipe has given satisfaction is evidenced by the fact that the plates have just arrived for manufacturing another length of about 30 miles, and the Government received an application a short time ago from the Transvaal asking if the contractor would be allowed to make a length of pipe for works in Africa before proceeding with our present contract. Unfortunately this could not be allowed. It may interest you to know that the plates for the new pipes are being manufactured in America by the Lukens Iron & Steel Co., and the ring bars have been ordered from Jones & Laughlin, Pittsburg, Pa.

I send you a sheet showing the final measurements of some pipe work recently completed and detailed. (See accompanying table.—Ed.)

The specifications for coating steel pipe used in our work are as follows:

Extract from Specifications for 24 and 18-in. Steel Pipes, Bundaleer Water-Works, Western Australia.

Clause 30. Immediately after testing, each pipe shall be thoroughly and effectually freed from rust and dirt to the satisfaction of the inspecting officer.

31. The coating composition shall consist of equal proportions of best refined Trinidad natural asphaltum and refined coal-tar, or such modification of the proportions as the Engineer-in-Chief may consider advisable. The tar shall be kept for about four hours at a temperature of 210°F. to permit of evaporation before being used. After these materials have been thoroughly mixed together, in a proper mixing bath, they shall be run into a horizontal dipping bath and maintained at a temperature of not less than 350°, nor more than 400°F. during the process of dipping.

As the mixture will deteriorate after a number of pipes have been dipped, it shall be cleaned and fresh materials, in correct proportions, added when ordered by the superintending officer. The bath must be occasionally emptied and replenished with new material.

32. No pipe shall be dipped until it has passed the hydrostatic test, nor till it has been approved by the superintending officer immediately before dipping. Every pipe shall be perfectly clean, dry and free throughout from rust when the coating is being applied. Immediately before being placed in the bath each pipe shall be dried by a blast of hot air.

33. Each pipe (but no joint-rings) shall be placed in the dipping bath and remain immersed in the composition for less than 15 minutes, and during the whole of that time shall be occasionally revolved. It shall then be hoisted out and the surplus material partially drained off it; the pipe shall then be dipped again into the bath and taken out and surplus coating allowed to drain off while being revolved, when sufficient approved, clean, dry sand shall be allowed to fall uniformly over the whole of the outer surface and be pressed into the coating by means of hand rollers. The coating shall be thoroughly set and hard before the pipe is removed.

34. The coating when cold must be even in thickness; firm, tough, and tenacious, with no tendency to crack, and must not run when exposed to the sun; and if it is at all brittle, or in any way defective, the contractor shall alter the proportions of asphalt and tar, or the temperatures, with the approval of the Engineer-in-Chief.

35. The asphalt coating on each pipe shall weigh not less than 9 oz. per sq. ft. of both sides taken together, the sand on the outside being included; and no pipe will be accepted on which the coating is less than that weight.

36. After testing, but before coating, each pipe, special pipe and joint ring, shall be weighed by the contractor in the presence of the inspecting officer.

After coating and sanding, the pipes and rings shall be again weighed for the gross weight and to test the thickness of the coating.

I forward also some drawings (Figs. 1 to 4), showing the new pipe, which is to be used on the Bundaleer Water-Works, now under construction. You will note that I have shown four descriptions of joints (ring, angle iron, spigot and expansion; only the latter is reproduced.—Ed.). This was done in order to have a price from the contractor for special connections, should such be required when carrying out the work. The joint used on the main line is a plain steel ring, 6 × ⅝ ins. I have tried the peculiar section which has been adopted on the Coolgardie work and do not care for it. There may be a slight saving of lead in its use, but the pipes do not readily lend themselves to inequalities of grade and direction with such a ring, and the setting up of the pipe in the plain ring with lead wedges is in my opinion a much better arrangement than trusting to the closeness of the center part of the ring to hold the ends of the pipes. At first we thought that a spigot ring would be necessary at the joint, as is usual with riveted pipes, but except for connection with stop-valves, where the grooving would not fit the locking-bar, the use of the spigot has been entirely abandoned and the locking-bar gives no trouble in the plain joint.

The peculiar expansion joint, shown by Fig. 1, is the result of my experience on another work. I had a 17-in. pipe laid on a single girder bridge of considerable length. This pipe was working under a pressure of 300 lbs. per sq. in., our temperature in the sun being about 170° F., which sometimes falls at night to 50 or 60° in summer. This pipe was fitted with the ordinary expansion joint, but the stuffing boxes had to be packed so tightly that the necessary movement for expansion and contraction was not allowed. I have therefore taken off these expensive fittings and put on the end of each pipe a flange as shown. The pipes have now been for some time in use under the full pressure. The curved flanges provide for the expansion and contraction, and the leakage which gave so much trouble at the ordinary joint has entirely ceased. This last item has an interesting bearing on the expansion joint for Coolgardie, which main was originally proposed to be laid above ground. I tried numerous designs for laying 80 miles of 16 and 17-in. steel main above ground, and came to the conclusion that such an arrangement would be altogether out of the question. The peculiar stuffing box originally intended to be used on the Coolgardie main (see Eng. News, Oct. 13, 1898), would not in my opinion work satisfactorily and I am glad it has not been adopted.

While on this subject, I may mention that in the construction of the Happy Valley Water-Works for the supply of this city, I was obliged to lay a long length of 6-ft. pipe above ground. This pipe is subject to only occasional pressure and therefore to all variations of temperature from below freezing point to over 170°F. in the sun. For this pipe I designed an expansion joint, as shown by Fig. 5. I also enclose a photograph, Fig. 6, which shows such main in position. This joint has given the most unqualified satisfaction. There has not been the slightest movement of the pipe, but it is quite manifest that such a joint would not be suitable for small pipes laid across country, as the men could not get inside to do the riveting, and in case any repairs being required such would be a serious matter.

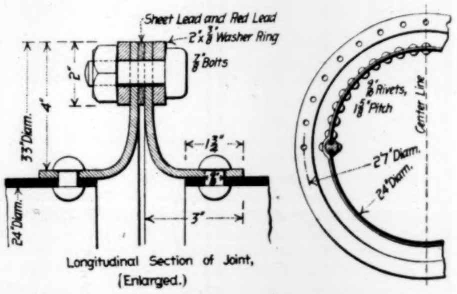


Fig. 1.—Expansion Joint for Bundaleer Water-Works, Western Australia.

Alex. B. Moncrieff, M. Inst. C. E., M. Am. Soc. C. E., Engineer-in-Chief.

From time to time questions have been raised as to the method of following sharp curves when laying these locking-bar pipes. I have found the introduction of cast-iron specials to be the most satisfactory arrangement, and as you will see from Figs. 1 to 3, this method has been adopted for the new Bundaleer works.

Detailed Cost of Laying Steel and Cast-Iron Water Pipe for Adelaide Water District, Western Australia.*

Items.	Length, size and material laid.			
	26-in. steel, 22,658 ft.	24-in. steel, 22,552 ft.	15-in. steel, 18,262 ft.	12-in. c.-i., 24,968 ft.
Steel pipes, including valves, specials, etc., delivered on ground....	$3.28	$2.81	$2.03	.....
Cast-iron pipes, including valves, specials, etc., delivered on ground.	.....	.....	.....	$1.61
Trenching	.21	.16	.09	.06
Filling	.10	.10	.04	.02
Laying and jointing, connecting branches, etc..........	.14	.12	.07	.09
Building culverts and retaining walls..........	.01	.02	.01	...
Supervision, etc.	.04	.04	.04	.01
Cost per lin. ft..........	3.77	3.25	2.28	1.79
Total cost	$85,802	$73,270	$41,709	$44,844

*The work included in this table extended from Darlington to Semaphore, and was laid in the four weeks ending Feb. 7, 1897.

EARLY ENGINEERING WORK IN THE UNITED STATES.*

By Desmond FitzGerald, Pres., Am. Soc. C. E.†

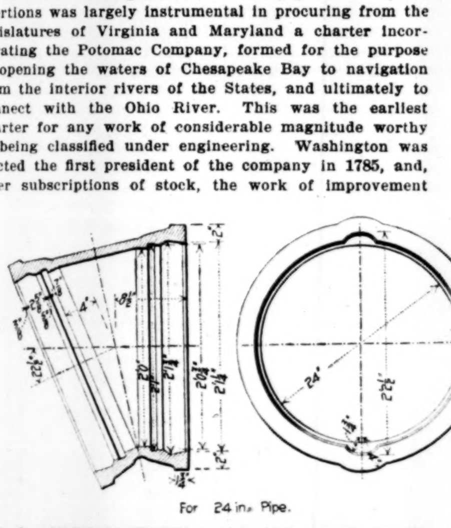
Those who have had occasion to study the early condition of engineering in this country and the lives of the fathers of the profession, must have been struck with the paucity of the literature of the subject. As we are apt, in the feverish hurry that surrounds the engrossing pursuits of the present day, to overlook the debt we owe to the founders of civil engineering in the United States, and as the close of the century is an appropriate time for historical review, I have concluded to call your attention to a few of the earliest public works constructed in this country, and particularly to the men who designed and built them.

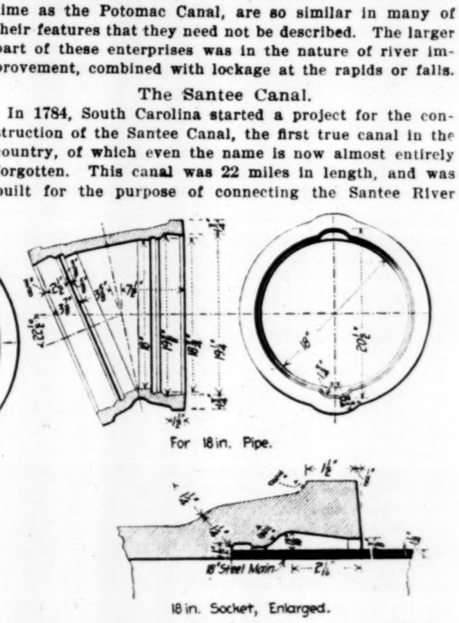
The history of engineering in America is naturally divided into four periods: (1) That from 1785 to 1800, embraced in the earliest public works of the country of the nature usually undertaken by the civil engineer. (2) That from 1810 to 1830, beginning with the revival of works of internal improvement after a long period of inaction, and extending to the invention of the railroads. (3) That from 1830 to 1848, beginning with railroads and extending to the formation of the engineering societies. (4) That from 1848 to the present time. Only a rapid survey of the first three of these periods will be attempted.

Before the Revolutionary War of 1776 the spirit of internal improvement had already begun to make itself manifest throughout the Colonies in various directions. Nowhere had this spirit taken more definite form than on the banks of the Potomac. To John Bellendine, of Fairfax County, Virginia, a person described as possessing skill and judgment in water-works, is probably due the credit of first putting in definite form a scheme for connecting the Potomac River with Monongahela, and the James with the Kanawha. Bellendine came as near being a civil engineer as any one else in the country at that time. He published, in 1773, his plans for constructing canals and locks for the improvement of the navigation of these rivers.

Washington, who was almost an engineer, had already planned projects for connecting the Atlantic Coast with the almost unknown wilds beyond the Alleghenies, but war stopped the hand of progress in public works, and it was not until peace had been declared that the country once more turned to works of internal improvement. Here Washington took a leading part, and by his exertions was largely instrumental in procuring from the legislatures of Virginia and Maryland a charter incorporating the Potomac Company, formed for the purpose of opening the waters of Chesapeake Bay to navigation from the interior rivers of the States, and ultimately to connect with the Ohio River. This was the earliest charter for any work of considerable magnitude worthy of being classified under engineering. Washington was elected the first president of the company in 1785, and, after subscriptions of stock, the work of improvement began. For some time this was confined to the removal of rocks from the bed of the Potomac River as far as the Great Falls, but the real difficulties of surmounting the 76 ft. of rise in these falls called for the services of an engineer. In a letter to Edmund Randolph, dated September 16, 1785, Washington wrote:

> And as the Great Falls are tremendous and the navigation thereof, in whatever manner it is attempted, will require much skill and practical knowledge in the execution; we propose, before this is undertaken, to invite a proper person from Europe, who has been employed in works of this kind, as a superintendent of it.


For 24 in. Pipe.


For 18in. Pipe.

18 in. Socket, Enlarged.

FIG. 4.—SPECIAL ELBOW CASTINGS FOR STEEL PIPE LINE, BUNDALEER WATER-WORKS.

It is probable that some foreign engineers advised and perhaps designed the locks around the Great Falls.

Work on the Potomac Canal languished toward the last of the century, and, in common with all other great undertakings of the day, slept until awakened many years later, when the Chesapeake and Ohio River Canal, which absorbed all the works of the old Potomac Company, was formed in 1823.

On January 5, 1786, an Act for cleaning and improving James River was obtained. Under this Act, the old James River Company constructed a canal around the Falls on James River, extending from Richmond to Westham, a distance of about seven miles, and improved the bed of the river by sluices as far as Buchanan.

The Dismal Swamp Canal, extending from a point on the Elizabeth River, near Norfolk, to Albermarle Sound in North Carolina, and passing through the Great Dismal Swamp, in the States of Virginia and North Carolina, was chartered in 1787, and a large amount of work was done before the close of the century; but progress was so slow that the actual connection of the waters of Chesapeake Bay with Albermarle Sound was not made until after the War of 1812.

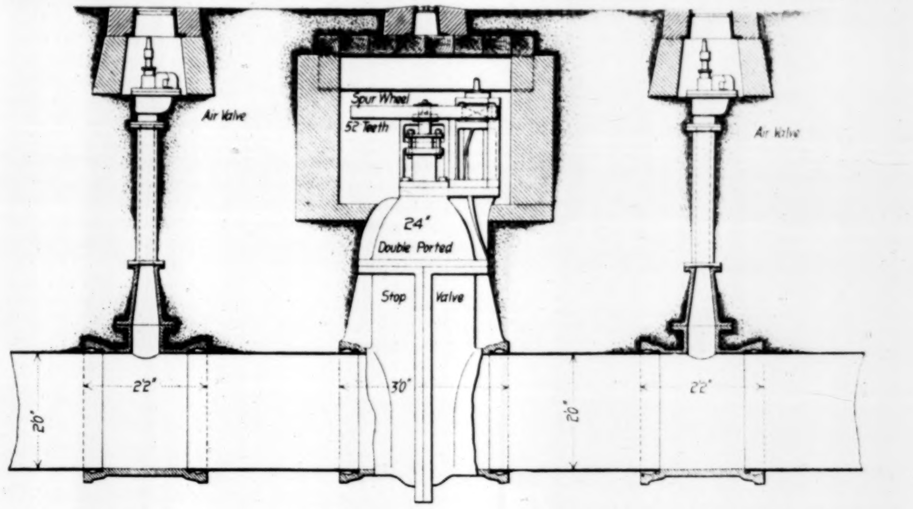


FIG. 3.—CAST-IRON STOP AND AIR VALVES FOR STEEL PIPE LINE, BUNDALEER WATER-WORKS.

The operations of the James River Company and the Dismal Swamp Canal, undertaken at about the same time as the Potomac Canal, are so similar in many of their features that they need not be described. The larger part of these enterprises was in the nature of river improvement, combined with lockage at the rapids or falls.

The Santee Canal.

In 1784, South Carolina started a project for the construction of the Santee Canal, the first true canal in the country, of which even the name is now almost entirely forgotten. This canal was 22 miles in length, and was built for the purpose of connecting the Santee River with the tidal headwaters of Cooper River, which empties into Charleston Harbor.

The charter for the Santee Canal was obtained March 22, 1786. Work was begun in 1793, and the canal was finished in 1800. As this was the first work of internal improvement constructed in this country, antedating the famous Middlesex Canal by about three years, it possesses an unusual interest in a consideration of the history of engineering in this country. The Chief Engineer and Director was Col. Christian Senf, a Swedish engineer, who was at that time Chief Engineer of the State of South Carolina. The total rise and fall of the canal was 103 ft., overcome by eight single and two double or coupled lift-locks, varying from 5 to 10 ft. lift, and built of stone or brick masonry with wooden gates. The boats were 54 ft. long, 9 ft. beam and 2½ ft. draft. The average dimensions of the canal were 35 ft. wide at top, 20 ft. at bottom, and 4 ft. depth of water. The canal was furnished with 25 flood gates, several overfalls, abutments and walls for bridges, and for 13 miles of its course the digging was 15 ft. deep. The work was constructed by negro laborers, two-thirds of them being men and one-third women, and they were paid £15 to £16 per year.

The reports of the engineer are exceedingly interesting. The following is an extract from one of them:

> You and the Board of Directors will be pleased to remember that from the beginning of the work I have never been able to meet with a tradesman or any other person to assist me who had ever been employed upon similar work. Of course, being obliged to lay out every kind of work myself, and to direct its execution, I have not been able to give you from time to time my progress, as is usual.

There is something heroic in the simple descriptions of this engineer, who alone undertook to carry his work to completion in the face of fevers, lack of facilities, and every conceivable obstacle. There is nowhere a reference to its being the first work of its kind in the country, no bombast, no flourish of trumpets, only the straightforward reports of the honest engineer striving to bring order out of chaos. The summit level of the canal was five miles in length, and was to have been fed by reservoirs and swamps, which, however, afterward proved insufficient, and this was one of the principal causes of the failure of the canal.

In 1880, Col. Q. A. Gillmore was requested to report upon the reopening of the canal, under authority of a provision in the River and Harbor Bill. The report was not favorable, but the engineers found the canal almost intact, although covered with a growth of timber and brush. The locks were generally in place, with the exception of the gates, which had gone to decay. On the advent of railroads, the canal was abandoned. The original cost of the canal was $650,667, and the ultimate cost $1,100,00[illegible] The company owned 110 slaves and 6,000 acres of land.

Early Pennsylvania Canals.

A project which was proposed and discussed long before the Revolutionary War, in fact by William Penn, in 1690, was that of uniting the Schuylkill and Susquehanna rivers by a canal. The first explorations were made by a committee of the American Philosophical Society in 1770. The same route was surveyed again, a little later, by the astronomer, David Rittenhouse. In 1789 a few public spirited citizens formed an association and proposed various plans to the Legislature, and in the following year commissioners were appointed to explore several routes. This action resulted in the formation of two companies.

The first was the Schuylkill & Susquehanna Navigation Co., incorporated in 1791, to open a communication between the Schuylkill and Susquehanna rivers from Reading on the Schuylkill to Middletown on the Susquehanna. The second was the Delaware & Schuylkill Navigation Co., incorporated in 1792, to open a canal from Philadelphia along the east branch of the Schuylkill, 16 miles, to Norristown.

As soon as the companies were organized, committees were appointed to superintend the commencement of the respective works. Unfortunately there was no engineer at that time in Pennsylvania competent to aid the committees; they, therefore, sent to England and engaged Mr. William Weston, an engineer of reputation, to come out and manage both works. In the meantime, the committees did not think it proper to remain idle. They commenced the respective undertakings, and had each well under way when Mr. Weston arrived, in January, 1793.

Early in the following year Mr. Weston made a report on the Schuylkill & Susquehanna navigation, to the effect that the unerring test of experience had proven the inefficiency of undertaking to open water communication by the beds of the creeks, and recommended the construction of a canal 70 miles in length from the Schuylkill to the Susquehanna. The expense he estimated at $821,330 in addition to the $400,000 already subscribed.

---

*Address delivered at the annual convention of the American Society of Civil Engineers, at Cape May, N. J., June 27, 1899.

†3 Mt. Vernon St., Boston, Mass.

The company soon became convinced that Mr. Weston was right. Anticipating legislative aid, they worked under Weston's guidance through 1794. In December, 1794, five locks of 6 ft. fall and two road bridges had been completed, and progress had been made on the sixth lock. In this state work was suspended, with $250,000 spent.

In December, 1794, Mr. Weston made a report in regard to the Delaware and Schuylkill project, in which he said that "one-third of the work, about 5 miles, is finished, and that contracts are formed and forming for a vigorous prosecution of the remainder," and that "the whole canal of 16 miles could be completed for the sum authorized, $400,000," and, "if the stockholders would punctually pay the sums subscribed by them, a toll for a part of the canal might be drawn in 1796, and the whole completed in 1797 or 1798." In spite of every effort, however, the work languished, and in 1796, when nearly 6 miles of the canal were navigable, the work entirely ceased. The sum of $221,710.06 had been spent on this undertaking.

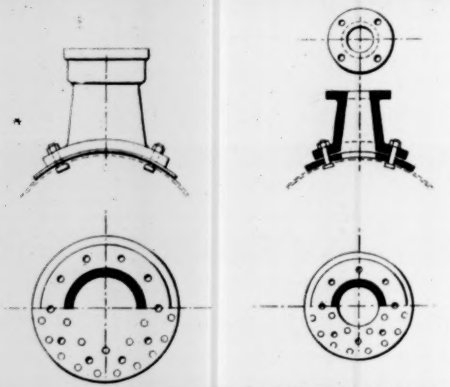


Fig. 2.—Branch Castings for Steel Pipe Line, Bundaleer Water-Works.

In 1811 these two companies were galvanized into life under the name of "The Union Canal," but no active operations were begun until 1821, when this historic work was begun and pushed to completion, in 1827, sixty-five years after the first survey, at a cost of $1,600,000.

The Schuylkill navigation was among the earliest works of this period. It was chartered in 1815, and work was commenced in 1816. The entire length of works controlled by the company, including slack-water navigation, was 108 miles. There were 31 dams and 120 locks in this distance, and the total lockage was 620 ft. Navigation was opened in 1825 for boats carrying 18 tons. The engineer was Thomas Oakes, and some of the works built by him are still in use. Oakes must have been an engineer of ability, and he probably came from England.

George Duncan, a Scotch engineer who succeeded him, built the old tunnel below Pottsville, and also the Tumbling Run reservoir system of the Schuylkill navigation, consisting of earth dams, one 48 ft. and the other 60 ft. in height. Duncan also designed and built the dams in the river above Reading, and the Duncan Canal, all now in use and described as admirable works.

Early Canals in New York.

While enthusiasm for the construction of work of inland navigation was aroused further to the South, the great State of New York was not idle. Many years before the close of the eighteenth century public attention had been directed toward the great valleys of the Mohawk and Hudson as furnishing a means of water communication between the city of New York and the Great Lakes. The first steps were not taken, however, until March, 1791, when an Act was obtained to open communication between Wood Creek and the Mohawk River, and also providing for a connection between Lake Champlain and the Hudson. The latter was known as the Northern Canal and the former as the Western Canal. Under this act, Mr. Abraham Hardenbergh, a skilful and experienced surveyor, assisted by Mr. Benjamin Wright, made the survey in September and October, 1791. Mr. Wright was destined later to a career of fame as one of the first native civil engineers in America.

In March, 1792, an important Act was passed by the Legislature of New York providing for "opening a lock navigation from the navigable part of Hudson River, to be extended to the Seneca and Ontario Lakes." This legislation gave practical form to the idea of connecting the Hudson with the Great Lakes.

The Western Inland Lock Navigation Co. immediately began active work on the improvement of the Oneida Lake, Mohawk and Seneca Rivers. These waters were opened from Schenectady to the Seneca Falls in 1796 for navigation by boats of 15 tons burden. The first locks were built of wood, as were those on the Potomac, and their decay and failure proved a serious blow to the stockholders.

William Weston was employed as engineer, and he rebuilt the locks with masonry, but at such a cost as to exhaust the resources of the company. It is stated that the wooden locks at the Little Falls, German Flats and Rome went to decay in about six years, and that they were rebuilt with brick, which again failed owing to the quality of the mortar, which was probably of lime.

The Middlesex Canal.

Following closely on the construction of the southern canals came the great undertaking of that day in New England—the Middlesex Canal, which had the honor of being the second real canal constructed in the United States. The charter was obtained in June, 1793, under the title of "Proprietors of the Middlesex Canal." Samuel Thompson, of Woburn, afterward Count Rumford, was engaged to run the levels, but the accuracy of his work was doubted by the directors, and on March 1, 1794, Col. Loammi Baldwin was authorized to proceed to Philadelphia and secure the services of Mr. Weston, who ran the levels in July, and on August 2d endorsed the feasibility of the canal and estimated the expense at $500,000. It was decided to proceed with its construction, and Col. Baldwin, the father of three distinguished civil engineers and the discoverer of the Baldwin apple, was appointed superintendent.

The Merrimac River flows in a southeasterly direction from New Hampshire, and, when within about 27 miles of Boston, abruptly turns to the northeast. It was intended, by means of the Middlesex Canal, to unite this angle of the river with Boston, and provide a market for the commerce of the river.

The beginning of the canal was at a point on the Merrimac River about two miles above the present City of Lowell, which at that time did not exist. Its length to the Charlestown mill-pond, the easterly terminus, was 27¼ miles. It was 30 ft. wide and 4 ft. deep; on its course were 7 aqueducts, 20 locks and 50 bridges. The Concord River was 37 ft. higher than the Merrimac and 107 ft. above tide, and was ample in volume to feed the canal in both directions. A stone guard lock was located on each bank of the Concord, with a floating towpath between. In the Merrimac itself there were three stone locks. Many of the structures were built of timber supported on stone, and these structures, which soon began to decay, were the source of much embarrassment and expense. The canal, to-day, can be traced, but not without difficulty. Portions of it have been absorbed into highways; sewers and water pipes are laid in its bed; and, at Wilmington, the stone sides of a lock form the cellar of a house.

The water was let into the canal in 1802, and it was opened for public use in 1803.

The managers had included in their far-reaching plans the completion of the navigation of the river for 80 miles, and actually built many other smaller canals around the falls and rapids of the Merrimac. These works required the constant expenditure of money. Some idea may be had of the far-reaching views of the projectors of the Middlesex Canal when it is concidered that they looked forward to a direct connection by water with Concord, N. H., and thence, by way of Sunapee Lake, to the Connecticut at Windsor, Vt., and thence to the St. Lawrence and Canada. Their dreams, however, were destined never to be realized. The building of the Boston and Lowell Railroad parallel to the canal was the signal for its decline; it was closed in 1846 and its charter was forfeited in 1859. The total cost of the canal was $613,000. The price of labor was $10 a month and board.

Inns were built along the route, where the boatmen congregated at night, as the canal was not allowed to be used after dark. Black strap, a mixture of rum and molasses, was the favorite drink of the boatmen and was sold at the price of 3 cents per glass.

It is related that Daniel Webster was engaged by the directors to plead one of their land damage cases of unusual interest, and that they paid him $100 as a retainer. As the day of the trial drew near an effort was made to reach Webster, but he was always away, either in New York or Philadelphia, and the manager who told the story plaintively added: "Our $100 has gone to profit and loss account."

Passenger Travel on Rivers and Canals.

Some idea of the discomforts attendant on river and canal travel in the early days may be formed from the following extracts from contemporaneous sources. The first is from an advertisement, printed in Cincinnati, of the first regular packet line between Pittsburg and Cincinnati, in 1794:

> Two boats for the present will start from Cincinnati to Pittsburg and return to Cincinnati in the following manner, viz.: First boat will leave Cincinnati this morning at 8 o'clock and return to Cincinnati so as to be ready to sail again in four weeks from this date. Second boat will leave Cincinnati on Saturday, the 30th instant, and return as above; and so regularly, each boat performing the voyage to and from Cincinnati to Pittsburg once in every four weeks. The proprietor of these boats having maturely considered the many inconveniences and dangers incident to the common method hitherto adopted of navigating the Ohio, and being influenced by a love of philanthropy and a desire of being serviceable to the public, has taken great pains to render the accommodations on board the boats as agreeable and convenient as they could possibly be made. No danger need be apprehended from the enemy, as every person on board will be under cover made proof to rifle balls, and convenient port-holes for firing out. Each of the boats is armed with six pieces, carrying a pound ball; also, a good number of muskets, and amply supplied with ammunition, strongly manned with choice men, and the master of approved knowledge.

The second extract is taken from a "Sketch of the Civil Engineering of North America," by David Stevenson, 1838:

> The canal traveling in many parts of America is conducted with so little regard for the comfort of passengers as to render it a very objectionable conveyance. The Americans place themselves entirely in the power and at the command of the captains of the canal-boats, who often use little discretion or civility in giving their orders, and strangers who are unaccustomed to such usage, and would willingly rebel against their tryanny, are in such cases compelled to be guided by the majority of voices, and quietly to submit to all that takes place, however disagreeable it may be. About eight o'clock in the evening every one is turned out of the cabin by the captain and his crew, who are occupied for some time after the cabin is cleared in suspending two rows of cots or hammocks from the ceiling, arrangen in three tiers one above another. At nine the whole company is ordered below, when the captain calls the names of passengers from the way-bill, and at the same time assigns to each his bed, which must immediately be taken possession of by its rightful owner on pain of his being obliged to occupy a place on the floor, should the number of passengers exceed the number of beds, a circumstance of very common occurrence in that locomotive land. I have spent several successive nights in this way, in a cabin only 40 ft. long by 11 ft. broad, with no less than forty passengers; while the deafening chorus produced by the croaking of the numberless bull-frogs that frequent the American swamps was so great as to render it often difficult to make one's self heard in conversation, and, of course, nearly impossible to sleep. The distribution of the beds appears to be generally regulated by the size of the passengers; those that are heaviest being placed in the berths next to the floor. The object of this arrangement is partly to ballast the boat properly, and partly, in the event of a breakdown, to render the consequence less disagreeable and dangerous to the unhappy beings in the lower pens. At five o'clock in the morning, all hands are turned out in the same abrupt and discourteous style, and forced to remain on deck in the cold morning air while the hammocks are removed and breakfast in preparation. This interval is occupied in the duties of the toilette, which is not the least amusing part of the arrangement. A tin vessel is placed at the stern of the boat, which every one washes and fills for his own use from the water of the canal, with a gigantic spoon formed of the same metal; a towel, a brush and a comb, intended for the general service, hang at the cabin door, the use of which, however, is fortunately quite optional. The breakfast is served between six and seven o'clock, dinner at eleven and tea at five.

The foregoing descriptions embrace the principal public works connected with the early history of the country. As a rule, they were unsuccessful, financially. Under the high-sounding title of "Lock and Canal Navigation," they consisted generally of efforts to improve the navigation of rivers by a removal of bowlders, bars and other obstacles. Training walls and chutes were also built to concentrate the flow of the water, and often the first freshet removed all traces of the work which had been prosecuted at a considerable cost in time and money.

The primitive idea was to turn the beds of the streams into canals, and to overcome the rapids and falls by locks or inclined planes. The latter certainly required the services of the trained engineer, and when the settlers could no longer prosecute the work without such service, recourse was had to Mr. Weston from England, or to other foreign engineers. With financial losses, it is natural that discouragement should follow, and that several years should elapse before the struggle was renewed.

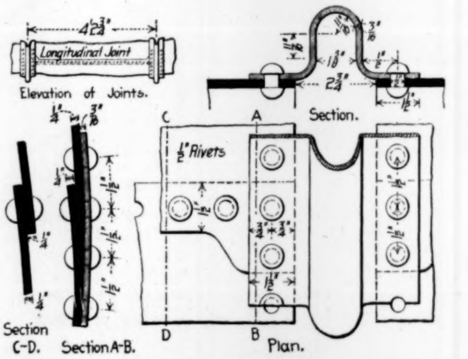


Fig. 5.—Details of Expansion Joint for 6-ft. Steel Pipe Line, Happy Valley Water-Works.

The Erie Canal and Its Engineers.

The great revival of works of internal improvement began in 1810, just before the beginning of hostilities between the United States and Great Britain, and this revival really marks the birth of engineering as a profession in this country. Up to that time, as we have seen, public works were undertaken in a spasmodic manner and without definite design. Ideas were abundant, and many of them were wonderfully far-reaching, but the means to carry them into effect and the men to clothe them with practical form were both lacking.

The great work which was to create the new profession of the engineer was the Erie Canal. In one sense this is true, in another, the profession created the Erie Canal, for the spirit of the engineer was in the air, and would have made itself manifest in some other form. It so happened that the Erie Canal, a magnificent undertaking for its day, had the honor of being the first great pioneer work of the American engineer. We must, therefore, take a brief glance at the work itself. It will not be possible to follow the history of the canal, or to examine with any minuteness the many interesting events connected with its execution. Fortunately they have been faithfully recorded, and can be found without difficulty. Whether one man or another is entitled to the glory of first pointing out the possibility of a connection between the waters of the Great Lakes and those of the Hudson does not enter into this discussion. We are more concerned in knowing how such a great project, with a multitude of details, all requiring the skill of the engineer, could have been carried to a successful termination in a land where there was apparently no engineer capable of the task.

Some of the preliminary surveys were made as early as 1808, but it was not until July 4, 1817, that the actual work of construction was begun. It was finished in 1825 and opened with great pomp and parade. The total length from Albany to Buffalo was 363 miles. The canal was 40 ft. wide at the top, 28 ft. wide at the bottom, and was 4 ft. deep. There were 84 locks on the main line, each 15 ft. by 90 ft. The total lockage was 688 ft On the canal were 18 aqueducts, some of them fine stone structures, notably that over the Genesee River which was 804 ft. long and contained 11 arches. Among the aqueducts across the Mohawk there was one with a length of 1,188 ft. One of the embankments was 72 ft. in height. The cost was upward of $10,000,000. By the completion of the Erie Canal, the time between Buffalo and Albany was reduced from twenty to ten days.

When the Board of Canal Commissioners was created, one of the first steps taken by it was that of selecting a chief engineer. William Weston, the English engineer who had been so prominent in some of the earlier enterprises connected with canal and lock navigation in America, was urged to cross the water again and undertake the work, and was offered a salary of $10,000, but his advancing years led him to decline the offer.

With an exalted faith in the ability of their fellow-countrymen, the Commission then resolved to entrust the construction of the canal, at that time the largest and most important work of canal construction in the world, to native talent. The line was divided into three divisions, in charge of James Geddes, Benjamin Wright and Charles Brodhead, and these men, with a few able associates, took up the burden, and, with faces turned toward the future, proceeded to execute the work.

The question naturally arises—how could these men, without text books or traditions to guide them, succeed in carrying out so important an undertaking? Geddes was a judge in the county in which he resided, and was 54 years of age. Wright was also a judge and had passed his 46th year. Bates and Roberts, their associates, were also judges. To understand the situation correctly, we must turn backward a page. In almost every frontier settlement could be found some man, more gifted than his fellows, who laid out farms, settled petty controversies in his county and became a judge, thus uniting surveying and the execution of the law. They were generally men of courage, energy and skill, and accustomed to solving all sorts of problems. They were essentially men of action, and many of them were men whose lives had been spent in the hard school of adversity.

Benjamin Wright was born in Connecticut on October 10, 1770. At an early age he began the work of surveying farms at Fort Stanwix, on what was then the border of civilization. Before the year 1800 it is said he had laid out into farms more than 500,000 acres in western New York. His first work with the level was on the old Western canals, of which Mr. Weston had been the engineer. In 1803 the company decided to have some levels taken. They owned a leveling instrument, but no one could be found who knew how to use it. Judge Wright was appealed to, and after a study of the instrument and, a trial, he succeeded in accomplishing the work, which led to other business for the company. What more natural than that he should have been employed in some of the preliminary work for the Erie Canal in 1811?

James Geddes was seven years the senior of Benjamin Wright. He was born in Pennsylvania on July 22, 1763. When an appropriation of $600 was made for some of the preliminary surveys of the Erie, Geddes was selected. He made a survey from Oneida Lake to Ontario, from Lewiston to Niagara Falls, and from Buffalo to a connection with the Seneca River, all for the sum of $673, and reported that a canal from Lake Erie to the Hudson was feasible.

Canvass White, one of the junior engineers employed upon the canal, was born on September 8, 1790, had had a fair common school and academy education, and was a man of scholarly instincts. In 1817 he left the work of construction and visited Europe for the purpose of studying canals in the old world; he traveled 2,000 miles on foot and brought back to the Erie Canal plans and instruments which were of incalculable benefit to the work. The structures built on the canal after his return were laid in cement made from rock which he discovered.

It is at all wonderful that men such as these pushed the Erie Canal to a successful completion? They felt their way along, working out each problem, as it came, with energy and determination. What they did not understand they conquered by diligent study, unwearied zeal and sound common sense. By the constant exercise of these qualities, they laid the foundations of the profession of the civil engineer in the United States.

The action of New York in regard to the Erie Canal was the means of kindling enthusiasm in other states, and many canals were started all over the country. A large number of engineers found employment in carrying on the surveys for these works and in superintending their construction.

Besides the names already mentioned, the following engineers began their careers on canal construction: John B. Jarvis, Horatio Allen, William J. McAlpine, David S. Bates, Nathan S. Roberts, William M. Roberts, Jesse L. Williams, Major David B. Douglass, Jonathan Knight, Sylvester Welch, Ashbel Welch, Edward Miller, Samuel Forrer, James Worrall, Samuel H. Kneass, John Wilson, W. Hasell Wilson, and the list might well be extended to include others. Some of these engineers were later prominently identified with railroad enterprises, and their careers more properly belong to that era.

Canvass White, who was one of the most distinguished among the early canal engineers, became Chief Engineer of the Union Canal, and Consulting Engineer for the Schuylkill Navigation and the Delaware and Chesapeake Canal. He was Chief Engineer of the Lehigh and of the Delaware and Raritan Canals. He died in 1834 in his 44th year. With his ability and character, had he been spared for a longer life, he would undoubtedly have left behind a brilliant record in the later developments of the country.

David Stanhope Bates was born June 10, 1777. He was well educated, and was a surveyor and judge in 1810. In 1817 he began his career on the Erie Canal, and was a Division Engineer from 1818 to 1824, and the execution of some of the most important structures on that work came under his supervision. Betweeen the years 1824 and 1829 he was in Ohio engaged in extensive works in that state, and later became Chief Engineer of the Chenango Canal, and also of the Genesee Valley Canal. Judge Bates afterward became interested in railroads, and in 1835 retired, with impaired health, from the active practice of his profession. He died November 28, 1839.

Nathan S. Roberts was born July 28, 1776, and entered the service of the Erie Canal in 1816. He rose rapidly in his profession, and in 1828 became Chief Engineer of the Pennsylvania Canal. From 1835 to 1841 he was associated with John B. Jervis and Holmes Hutchinson in the enlargement of the Erie Canal. He died November 24, 1852.

As a search for the fathers of the profession must, undoubtedly, be made among these early canal engineers, and it is of interest to know if among them there is one pre-eminently entitled to be designated as "The Father of the Profession," the careers of four of the most prominent have been selected for examination. They are James Geddes, Benjamin Wright, Loammi Baldwin and John B. Jervis, and their names are mentioned in the order of their birth.

In addition to his work on the surveys of the Erie Canal, James Geddes, in 1818, was appointed Chief Engineer of the Champlain Canal, and remained in charge of its construction until 1822, when he was selected to make the surveys for a canal from the Ohio River to Lake Erie, and in 1823 was called to Maine to locate a canal from Sebago pond to tide water at Westbrook. In 1827 he entered the service of the General Government on the location of the Chesapeake & Ohio Canal, and in 1828 was employed by Pennsylvania on canals in that state. He died on August 19, 1838, at the age of 75.

While Benjamin Wright was engaged upon the building of the Erie Canal, he was consulted on the Northampton, Blackstone, Chesapeake & Delaware canals and by the State of Virginia on a proposed canal from Richmond to the Ohio. In 1824 he became Chief Engineer of the Chesepeake & Delaware Canal, and in 1825 Consulting Engineer for the Delaware & Hudson. In 1828 he became Chief Engineer of the Chesepeake & Ohio Canal, a position which he resigned in 1831. In 1832 he was appointed Street Commissioner of the city of New York, and subsequently Chief Engineer of the Hudson Railroad, and Consulting Engineer of the St. Lawrence Ship Canal, Canada, and also of the Welland Canal. Later, he was employed to survey the route for the New York & Erie Railroad, and in 1835 he was called to Havana to advise on railroad projects. During the next four years he was engaged on several canal and railroad plans, but remained principally in Virginia, to which state he had been invited after the completion of the Erie Railroad survey. He died on August 24, 1842, being then nearly 72 years of age.

Loammi Baldwin was born May 26, 1780. He was the son of Col. Loammi Baldwin, who superintended the construction of the Middlesex Canal. The son, also a colonel, was graduated from Harvard College with the famous class of 1800. In 1807 he visited England to study engineering. One of his earliest works was the construction of Fort Strong on Noddle Island. Between the years 1817 and 1820 he was employed in Virginia on various works of internal improvement. In 1821 he was appointed Engineer of the Union Canal in Pennsylvania. In 1824 he was in Europe, and it was at this time that he laid the foundation for his large library of works on engineering. From 1827 to 1834 he was employed in designing the masonry dry-docks at Charlestown, Mass., and at Norfolk, Va., for the Government, both of these works being carried on at the same time. It was in 1834 that he made an able and elaborate report on the proposed water supply of Boston. His death occurred June 30, 1838, at the age of 58.

John B. Jervis was born Dec. 14, 1795. His education was only such as could be picked up in the common schools of a new country. In 1817 he began his engineering career as an axeman on the Erie Canal, but was soon made Resident Engineer and was advanced to several responsible positions, remaining on the work until its completion in 1825. The following is a brief summary of his remarkable career:

1825-30.—Chief Engineer of the Delaware & Hudson Canal.
1830.—Chief Engineer of the Albany & Schenectady Railroad; and soon afterward Chief Engineer of the Schenectady & Saratoga R. R.
1833.—Chief Engineer of the Chenango Canal.
1836.—Chief Engineer of the Croton Aqueduct.
1846.—Consulting Engineer of Cochituate Water-Works.
1847.—Chief Engineer of the Hudson River R. R.
1850.—He visited Europe and on his return was made Chief Engineer of the Michigan Southern & Northern Indiana R. R.
1851.—President of the Chicago & Rock Island R. R.
1861.—General Superintendent of the Pittsburg, Fort Wayne & Chicago R. R.
1864.—Chief Engineer of the Pittsburg, Fort Wayne & Chicago R. R.
1868.—He was made one of the first trustees of the Rome Merchant Iron Mill Co.

For more than 70 years Mr. Jervis was an active worker in his profession, and at the advanced age of 83 he wrote a lecture on "Industrial Economy." In December, 1881, he was summoned to New York by Isaac Newton and E. S. Chesbrough in consultation on the plans for the new Croton Aqueduct. He was then 86 years of age. Mr. Jervis died Jan. 12, 1885. Owing to his wonderfully long career I am obliged to trespass upon the fourth period of American engineering, beginning with the formation of the engineering societies, as Mr. Jervis became a Member of this society in 1867 and an Honorary Member in 1868.

I leave to the wisdom of the Society the selection from these four names of the one most richly deserving the title of "The Father of his Profession in the United States."

The Beginning of the Railway Era.

The third period of American engineering was that beginning with the introduction of railroads in 1827. At this period has been already fully described by others, it will be but briefly alluded to, and only for the purpose of completing the connection to the founding of the engineering societies.

We have seen that the judges were engineers of the early canals, and it is also true that the majors and colonels were engineers of many of the early railroads. As there was a large demand for men of technical training, the government allowed the graduates of West Point to enter the service of the railroads, and thus it happened that engineers with military titles, and sometimes with the organization of the brigade, could be found laying out the locations and superintending the construction of the early lines. William Gibbs McNeill, George W. Whistler, and John Childe were officers in the army. On the other hand, Horatio Allen, Jonathan Knight, Benjamin H. Latrobe, Moncure Robinson and William Milnor Roberts were from civil life.

The early conceptions of Oliver Evans, John Stevens and Robert Fulton, and also the old colliery and quarry tramways were preliminary steps to the advent of the railroad. In 1825 William Strickland was sent to England by a number of public-spirited citizens of Philadelphia, and he made some interesting reports. The famous Quincy Railroad was built by Gridley Bryant in 1826, but it was only three miles long, and, like all the first railroads, was built as a horse railroad. It was followed in 1827 by the Mauch Chunk road, 9 miles long, connecting the mines with the Lehigh River, which, like several other tramways, was simply an adjunct to a canal. It is worthy of note that within ten years from this time there were no less than 56 railroads in active operation in the United States.

The first railroad of importance was the Baltimore & Ohio. It occupies the same position among the railroads that the Erie Canal occupies among the pioneer canals. It was incorporated in 1827, a cornerstone was laid on July 4, 1828, and the railroad was practically opened in 1830. It was completed to Harper's Ferry, 82 miles from Baltimore, in 1834, at a cost of $4,000,000. It was constructed for the use of horses as a motive power, and it was only after much experimenting that locomotives were introduced. The roadbed was formed with granite sills plated with flat iron bars, which had an uncomfortable way of curling up under the traffic, and were called "snake heads;" occasionally they would break off and come up through the floors of the cars. Although every roadbed from that time to the present has been a source of trouble and expense for maintenance, the term "permanent way" was used at an early date, and is still used to describe what is actually far from permanent in construction.

Jonathan Knight and Col. Stephen H. Long made the first survey for the Baltimore & Ohio R. R., and Jonathan Knight was the first Chief Engineer. He was without special education, but was a man of remarkable mental capacity. He was one of the old farmers and surveyors who worked his way to the highest station by unremitting toil, and the exercise of sturdy and manly qualities. In 1842 Knight resigned his position and retired to his farm, but was afterwards employed as a consulting engineer. Benjamin H. Latrobe succeeded Mr. Knight as Chief Engineer of the Baltimore & Ohio, and was among the most distinguished of the railroad engineers.

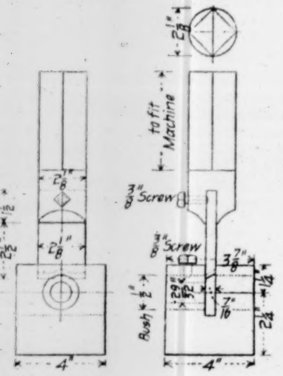


Fig. 1.—Device for Cutting Off and Squaring Ends of Iron for Stay Bolts; Cleveland, Cincinnati, Chicago & St. Louis Ry.

Capt. John Childe, born 1802, died 1858, was a consulting engineer on the Baltimore & Ohio R. R. with Knight and Latrobe, and, like his associates, left a long record of works accomplished in various directions. His own words were, "This is a glorious world and there is much to do in it."

Horatio Allen, born 1802, died 1889, was one of the Nestors of railroad construction in this country. He was first associated with Benjamin Wright on the Chesapeake & Delaware Canal in 1824, and afterward became an assistant to John B. Jervis on the Delaware & Hudson Canal. In 1827 Mr. Jervis gave his assistant leave of absence to visit Europe,and in England Mr. Allen made the acquaintance of George Stephenson, and finally purchased three locomotives which he brought back with him. One of these, the "Stourbridge Lion," he put together and ran on the Delaware & Hudson R. R. in 1829 This was the first locomotive ever tested on an American railroad.

In 1829, Mr. Allen was made Chief Engineer of the South Carolina Railroad, which he designed for a steam railroad, the first in the world intended for locomotives, and the first long railroad built in the United States. It extended from Charleston to Augusta, Ga., 136 miles. The first hundred miles of railroad iron ever laid in one continuous line was laid on this railroad.

From 1834 to 1837 Mr. Allen was abroad, and on his return was engaged as Principal Assistant Engineer on the Croton Aqueduct, and afterward became one of the Croton Commissioners. In 1842 he became one of the proprietors of the Novelty Iron Works, and was President until 1870. He was President of the New York & Erie R. R. and its Consulting Engineer. Mr. Allen was also Consulting Engineer of the Panama Railroad, and his last official position was that of Consulting Engineer of the East River Bridge. Mr. Allen became a Member of this Society in 1867, was President from 1871 to 1873, and became an Honorary Member in 1874.

One of the most distinguished of the early railroad engineers was William Gibbs McNeill, of North Carolina. He was graduated from the Military Academy in 1817. He was employed upon the Chesapeake & Ohio Canal, 1824, the Baltimore & Ohio Railroad 1827, and the Baltimore & Susquehanna 1830. He resigned from the army in 1837, with the rank of major by brevet. He was either Chief Engineer or Assistant Engineer of the following railroads: Paterson & Hudson, Boston & Providence, Providence & Stonington, Taunton & New Bedford, Long Island, Western of Massachusetts (now the Boston & Albany), and others. In 1842 he put down the Dorr Rebellion in Rhode Island, and was made a Major-General of the militia. He died Feb. 16, 1853.

George W. Whistler, born May 19, 1800, was graduated from West Point, and in 1828 was sent to England with McNeill and Knight in behalf of the Baltimore & Ohio R. R. He was employed on several other roads, and in 1833 resigned from the army. In 1834 he became Engineer for the Proprietors of Locks and Canals, Lowell, Mass., and later aided McNeill in constructing the Western Railroad of Massachusetts. In 1842 Whistler went to Russia to build the road from St. Petersburg to Moscow, and died in that service April 7, 1849. Whistler's fame added fresh laurels to the profession of engineering. One of his sons is the distinguished artist, James A. McNeill Whistler, of London.

Among other engineers who attained celebrity in this branch of the profession were James E. Williams, William Milnor Roberts (a statement of whose remarkable career may be found in the records of this Society), James Laurie, Moncure Robinson, J. Edgar Thomson, James P. Kirkwood, William J. McAlpine, Ellis S. Chesbrough, and others whose names deserve mention, but their lives and works, as a rule, have been either recorded in the biographies of the Society or they encroach upon a later period of engineering.

The venerable W. Hasell Wilson, now living, was among the early engineers employed upon the Baltimore & Ohio R. R., and he has written some of the most interesting accounts of the pioneer railroads. Mr. Wilson's father was an old canal engineer, and his gradfather and great-grandfather were employed in engineering pursuits. Mr. Wilson's sons, the Wilson Brothers, of Philadelphia, are prominent in the profession, and their sons are now entering the field, so that we have in connection with this family of engineers the noteworthy spectacle of six generations, in direct descent, engaged in the same profession, and five generations in this country.

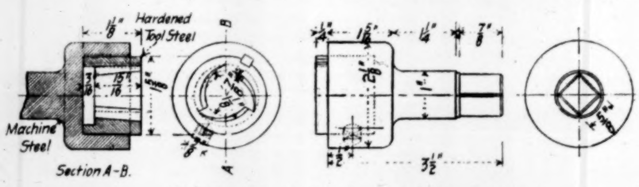


Fig. 3.—Clutch for Screwing Stay Bolts Into Boiler; Atchison, Topeka & Santa Fe Ry.

No notice has been taken of the work of the bridge builders, but they should not be forgotten. As early as 1792 Timothy Palmer began to build bridges over some of the largest rivers. In 1806 he completed the Philadelphia Bridge over the Schuylkill. Mr. Weston designed the coffer-dams for the piers, which were in deep water. At about this time Theodore Burr and Louis Wernwag began to build long-span wooden bridges, in which they accomplished some remarkable work. They were followed by Squire Whipple and that Meteoric genius, Charles Ellet, Jr., whose assistant, John A. Roebling, designed the grand suspension bridges so well known to the profession. An interesting historical résumé of the early bridges will be found in Mr. Theodore Cooper's able paper on "American Railroad Bridges," published in the Transactions of this Society in July, 1889.

The foregoing review has been prepared for the purpose of giving in connected form an idea of some of the most noteworthy among the earliest public works of the civil engineer, with brief outlines of the lives of the fathers of the profession in the United States.

There is much to be gained from a careful consideration of the important work accomplished by these noble and self-sacrificing men, who, in the face of almost insurmountable difficulties, successfully laid the foundations for the commanding position which the profession now enjoys. Some of the works which they created have long since been swept away in the advance of population, others have been absorbed in the larger developments of succeeding generations, but many still survive as living monuments to their constructive skill. In any event, the heroic struggles and the masterly achievements of the early engineers are deeply engraved in the history of every undertaking which their busy brains designed or their willing hands executed. This is due largely to the disinterested nature of their services, which were directed to the welfare of the public rather than to the advancement of their own glory. Even their lives were sometimes sacrificed to the sense of duty. They sowed and others have reaped the harvest from their honest and faithful toil. No eulogy we can pronounce upon their lives will add to the luster of their fame, but it will aid us to recall the debt of gratitude we owe to our predecessors. However permanent, however useful, however grand the engineering works of the present day may be, their success is due to the failures and successes of the works that have preceded them. In these closing hours of the nineteenth century, which has witnessed the rise and progress of the civil engineer in America, we may well glance backward to gain fresh inspiration from the courage, devotion and achievements of the early founders of the profession. A just pride in their work will lead us to emulate their example and to be faithful in our day and generation to the inheritance derived from their talents and industry.

BEST METHOD OF APPLYING STAY BOLTS TO LOCOMOTIVE BOILERS.*

Through the medium usually employed—the circular of inquiry—the committee has obtained the experience of many of the members. The replies to these questions show that they were carefully prepared with a view of furnishing the committee all information required. It has been thought best to submit the report showing, first, the process of manufacture of stay bolts, and the subject will be considered under the several headings to indicate the same.

Cutting Stay Bolts from the Bars.—The general practice is to cut stay bolts off to the required length by a concave cutter in a shearing machine. The Pennsylvania Co. cuts them off in a turret lathe. The C. C. C. & St. L. Ry. uses the device shown in Fig. 1. The advantage in the use of this device is that the bolt is held more firmly, while being sheared, than in the ordinary concave shears, and it cuts the ends off squarely. When the concave cutter is used there is more or less tendency for the stay bolt to raise up while shear is cutting, and the result is the end is not cut off squarely. There is no patent on this device.

Making Square Ends on Stay Bolts.—The usual method of making square heads is by the use of a bolt header. The Buffalo & Susquehanna R. R. makes them with dies under a steam hammer; the Chicago, Burlington & Quincy R. R. mills off square at end of stay bolt; the Chicago & North-Western Ry. makes the square with a punch under shears; the C. C. C. & St. L. Ry. does the same with the device shown in Fig. 2. Heads can be put on with this device by one man at the rate of 300 per hour. An ordinary bolt header can do this work at the rate of 300 per hour, requiring, however, one man and a helper to operate it.

Headless Bolts.—Several members report that they do not square ends. The stay bolts are screwed into boiler by the aid of various devices. The Chicago, Burlington & Quincy Ry. uses a patented eccentric die, and the Chicago & West Michigan Ry. uses a chuck for this purpose. The Northern Pacific Ry. reports the use of a device for screwing bolts into fire box. The device used by the Atchison, Topeka & Santa Fe is shown in Fig. 3. It is not patented. The Chicago & Eastern Illinois R. R. has tried headless bolts, but has abandoned their use, for the reason that after screwing them in with an air motor an adjustment must be made by the use of an alligator wrench in order to move the bolt just far enough to rivet it properly. The time used in adjusting and removing the alligator wrench more than balances the cost of forging the square ends on bolts.

Cutting Threads.—The Chicago, Milwaukee & St. Paul Ry. report the use of a six-spindle cutting machine—running the bolts through twice; the first time roughing them down very nearly to size and the second time with dies that are in perfect condition—only requiring to straighten up, and cutting but little additional thread. The Delaware & Hudson Canal Co. also take two cuts on stay bolts—the second cut being a very light one to finish. A better thread can be obtained by this method, though the usual practice is to take but one cut over a stay bolt.

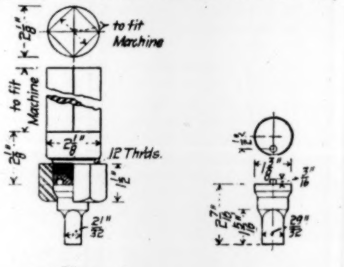


Fig. 2.—Device for Making Square Ends on Stay Bolts; Cleveland, Cincinnati, Chicago & St. Louis Ry.

A number of roads report the use of a lead screw attachment an essential to produce stay bolts with threads of accurate pitch, viz.: Erie, Lehigh Valley, Baltimore & Ohio, Grand Rapids & Indiana, Chicago Great-Western, Delaware, Lackawanna & Western, Chesapeake & Ohio, Penna. Lines west of Pittsburg, Philadelphia, Reading & New England, Mineapolis, St. Paul & Sault Ste. Marie, Northern Pacific, Rio Grande Western, Chicago, Rock Island & Pacific, Buffalo & Susquehanna and Chicago & Eastern Illinois.

The lubricant reported as giving the best results in cutting stay bolts is lard oil. Summer cottonseed oil is as good, and dies will remain sharp as long with it as with lard oil, but after bolts are cut it is more liable to gum over the threads. This, however, has not been considered objectionable, except when bolts are prepared and stored for some time before they are used. The Lehigh Valley R. R. reports that the best lubricant they have found is two-thirds raw linseed oil and one-third signal oil. The Chicago, Milwaukee & St. Paul Ry. uses bolt-cutting oil, which consists of 60% Natural West Virginia oil, 15% fish oil and 25% No. 1 lard oil. This was found entirely satisfactory.

---

*Abstract of committee report presented at the annual convention of the Mastern Mechanics' Association at Old Point Comfort, Va., June 19 to 21, 1899.

Special Forms of Stay Bolts.—The Erie R. R. uses upset ends on radial stays; the Chicago, Burlington & Quincy Ry. turns stay bolts down in center with a Niles screw machine; the Boston & Maine R. R. swages them down in the middle instead of upsetting the ends; the Rio Grande Western Ry. cuts them down in center below bottom of threads in a bolt cutter, with blind dies, working with a lead screw; the Chicago Great-Western Ry. reports the use of crown sheet stay bolts with threads turned off in the middle—the work being done in a turret lathe; the standard practice of the Lehigh Valley R. R. is to upset both ends for about 1 in., on which threads are cut, the center of bolt being left blank; the Northern Pacific Ry. reports that all long stay bolts are turned smaller in diameter at center than at ends, the work being done on a "Gisholt" machine; the Union Pacific Ry. turns stay bolts down in center in a lathe.

Preparing Stay-Bolt Holes.—The following roads report preparing stay-bolt holes in fire boxes by first punching them smaller than required size and then reaming them to size—thus removing disturbed metal, viz.: Delaware & Hudson Canal Co., Chicago & North-Western, Lake Shore & Michigan Southern, Missouri Pacific, Minneapolis, St. Paul & Sault Ste. Marie, Delaware, Lackawanna & Western, Chicago Great-Western, Lehigh Valley, Norfolk & Western, Chicago, Milwaukee & St. Paul, Northern Pacific, St. Louis & San Francisco. The following roads report drilling stay-bolt holes in fire-boxes, viz.: Chicago & North-Western, Cleveland, Lorain & Wheeling, Erie, Chicago, Burlington & Quincy, Duluth, South Shore & Atlantic, Southern, New York, Ontario & Western, Buffalo & Susquehanna; Chicago, Rock Island & Pacific; Penna. Lines west of Pittsburg, and Grand Rapids & Indiana. A large number of roads report the use of ordinary stay-bolt taps. A number, however, claim advantages in the use of the "Echols" patent stay-bolt tap made by Pratt & Whitney. The principle of this tap is the omission of each alternate tooth; each cutting tooth is followed by a space which gives a freedom of action to the cutting teeth, impossible in the old style, thus decreasing the resistance from 30 to 50%.

"Detector" Holes in Solid Stay Bolts.—The general practice is to drill stay bolts after they are in position. A few members report punching these holes by means of a steel-wire punch in a bolt-heading machine. The Chicago & Eastern Illinois R. R. uses an air motor attached to a framework allowing the drill to be set at any angle. This device is illustrated in Fig. 4. In making and applying stay bolts to locomotive boilers, two important factors must be carefully considered: The stay-bolt tap and the hob tap which cuts the dies in bolt-cutting machine must be true to pitch, and then the machine must have some special device for making the threads true to pitch. Cutting stay bolts true to pitch is a subject that deserves more investigation, we think, than any other detail connected with making and applying them properly. The weak point in a great many shops is in cutting stay bolts untrue to pitch. It has been found that accurately pitched dies will not produce true-pitched bolts. Pratt & Whitney write the committee that

> the problem of making a tap with long thread and keeping that thread to approximately correct lead has been a very annoying one to us, and doubtless to others, and is still annoying, for the very reason that we cannot rely upon the extent to which steel will change and the manner in which the change will take place. We overcome this very largely, however, by having carefully annealed steel to begin with: having the annealing as uniform as possible, and threading the tap with a screw which is made expressly for the work, and which has an error approximately the error which takes place in the tap in the hardening operation; i. e., long experience teaches us that steel will change in a certain direction. In the great majority of cases this direction is toward the shortening rather than the lengthening. We accordingly make the lead screw of our lathe long, as stated above, to compensate for the shrinkage or shortening that will take place in the steel when hardening. We very often have to give the tool a double shrinkage in very special cases. What we mean by double shrinkage is hardening the tool and reannealing before the final finish, threading on all important taps that have any special length of thread. We confine the error to .0015 per in. or .18 in. per ft."

Correctly cut dies alone will not cut true-pitch stay bolts; to insure stay bolts being cut true to pitch, two methods have been employed: A lead screw attached to the carriage of a bolt-cutter is one way to accomplish this, and the other is the lead-controlling feature employed by the Jones & Lamson Machine Co. in the dies used in their flat-turret lathe. The Acme Machinery Company writes the committee as follows:

> All dies that we have any knowledge of gain threads and lose pitch when cutting threads. Some of our expert die-makers can grind a set of dies so that they can be made to do "most anything," but that does not help the "rank and file," into whose hands such a machine falls. All kinds of schemes and contrivances have been made and used in trying to correct the disposition of a set of dies to cut out of pitch. Supposing, for instance, the rear teeth of a set of dies would act as a nut; they would certainly begin with an error, because the leading teeth are apt to begin with more or less error, as they "nibble" at the end of a bolt.

At the New York meeting of the American Society of Mechanical Engineers, in December, 1897, Mr. James Hartness, of Jones & Lamson Co., read a paper on a stay-bolt threading device which has some valuable features, especially for radial stays, where there are threads on both ends of stay bolts and long blank spaces between. We quote from the paper:

> The scheme may be briefly and perhaps completely described as "Tandem" dies for simultaneously threading both ends of a stay bolt to insure correspondence in lead. These tandem dies are designed for use in a turret lathe, and cannot be applied to a bolt cutter. Mr. Hartness further states that: Stay bolts are mostly cut by dies permitted to control their own lead; occasionally, however, a lead screw is used to govern the pitch of the die. The lead-screw scheme seldom controls the lead of the die at the beginning of its cut, on account of the slackness of the slides and intermediate connections; hence the dies usually has a chance to cut a very incorrect lead before the screw has taken up the "slack" and "spring" of intermediate parts. The dies are described as follows: The teeth at the front of the die have a cutting clearance, while the teeth at the back of the die have no clearance, but instead, ride on the thread and control the lead. So accurate is the lead-controlling feature that regular dies for market seldom have an error in lead greater than 1-64 in. in 18 ins., which is less than ¼ the average error in standard taps.

The committee has samples of screw-cutting done by the use of a lead screw on a bolt cutter, and also by the use of a Hartness die. Both methods give equally good results, so far as can be judged by the samples. The investigations of the committee lead it to believe that the best method of making and applying stay bolts is as follows: Cut the stay bolts from the bars by means of a shearing machine; make square ends by the use of a bolt-heading machine, or punching the metal from the bar to form a head; cut threads in a bolt cutter, having a lead screw, or on a turret machine having special dies that will cut true to pitch. For a cutting lubricant, lard oil is the best, with yellow cottonseed oil a close second. In preparing the stay-bolt holes, we recommend that: In the fire-box, they should be drilled; in the shell of boiler, punched ⅛-in. smaller than required size, and the remainder reamed out with a reamer on end of stay bolt tap. Holes should be tapped with some form of air or electric motor, and stay bolts screwed in with same device. We also recommend that stay-bolt taps, and hob taps for cutting stay-bolt dies, be purchased from some reputable maker in preference to making them at a railroad shop. Stay-bolt and hob tap making requires special skill and most accurate tools, which are not always available at railroad shops. For cutting off stay bolts, no device appears to answer for all bolts. The best practice seems to be as follows: Where bolts are of uniform length, and are at right angles with sheets, as in vertical water space surrounding fire-box, it is best to "nick" the bolts in a lathe to the right length; after being screwed into place a slight tap on the end is sufficient to break them off. For bolts that require to be cut off at an angle, an electric saw can be used to advantage; as in cutting off radial stay bolts, outside of boiler. A pneumatic cutting machine can be used to advantage for cutting off bolts of variable lengths after they have been screwed into place, where it would not pay to handle them singly in a lathe or cutting machine.

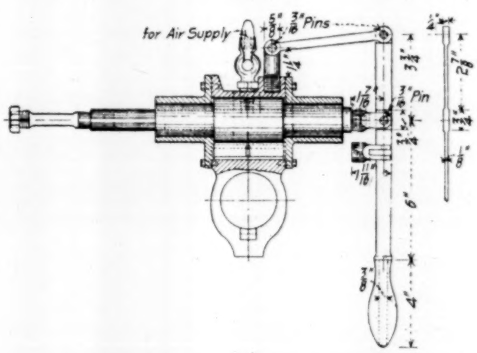


Fig. 4.—Air Motor for Drilling Detector Holes in Stay Bolts; Chicago & Eastern Illinois R. R.

The committee knows of no better way of riveting stay bolts than the well-known method with the common hammer, and a holding-on hammer at the other end of the stay bolt. It is the committee's opinion that some form of air motor for drilling the "detector" holes in stay bolts is preferable to punching them. The objections to punching detector holes is that while stay bolts are being riveted the holes close up and require to be opened with a drift. When the bolt is drilled after it has been riveted there is no further work to be done.

RECENT PRACTICE IN PURIFYING FEED WATER FOR LOCOMOTIVES.

One of the most annoying problems with which railway master mechanics have to deal in many sections of the United States is that of securing reasonably pure water for locomotive boilers. The troubles which occur in boilers from using impure water are almost too familiar to demand mention. The accumulation of mud and scale upon the tubes and crown sheet, the clogging up of the spaces around the fire-box and flues, leaky stay-bolts and flues, water foaming, and the bulging, cracking, furrowing, pitting and burning out the fire-box sheets are, however, some of them. Naturally the attempt has been made to overcome these troubles by purifying the feed water. In some cases the work was not carried on very systematically, but on the whole it has been persistent, and has resulted in much improved conditions. Some of the methods which have been used are: Filtering, treatment in wayside tanks, and introducing chemicals into the engine tender tanks and boiler. Other methods are the use of blow-off cocks to force the sludge from the boiler, feed-water heaters, mechanical boiler cleansers, etc. Lime, carbonate of soda, tri-sodium phosphate and tannin are some of the chemicals which have been used, besides a host of patent compositions, purges, boiler oils, etc. These purifying methods cost all the way from 15 cts. per 1,000 miles of locomotive mileage to between $3 and $4 per 1,000 miles. The cost of purification as well as the methods adopted to accomplish it are naturally not uniform. Each method, however, seems to have given good results in one respect or another, and to have warranted the expense of carrying it on.

The foregoing facts have been well exhibited in a report presented by a special committee of master mechanics at the convention of the Master Mechanics' Association at Old Point Comfort, Va., last week, from which we summarize the following statements of actual present practice.

Purification by Chemicals.

Of those answering the circular who have adopted purifying methods, the majority use soda ash, introducing it direct to the tender or boiler, and dispose of the sludge by blowing and washing out. One member says:

> Our difficulties have been much ameliorated by the introduction of soda ash. The most marked results have been with through passenger trains in Illinois. Formerly we could not run our flues with any degree of security more than 50,000 miles. Since the introduction of soda ash we get a mileage of 130,000 to 150,000 from flues without removing them; and by the introduction of pneumatic blow-off cocks the time between washouts has been increased.

The experience of the Chicago, Milwaukee & St. Paul Co. with soda ash extends over a period of twelve years, during which time it has been regularly used on all divisions of the system, and for a number of years the results have been uniformly beneficial, but it was not until a thorough system of boiler washing was inaugurated and a competent man installed as boiler-washing inspector, whose duty it was to visit all roundhouses, inspect boilers and give instructions in blowing and washing out, that best results were obtained. In the waters where carbonates and sulphates are present in such quantities that to add sufficient soda ash to precipitate the lime salts would give such a concentration of alkali in the boiler as to cause a constant foaming, it has not been possible to entirely neutralize the scale-making properties, but they have been so much improved that the life and mileage of flues and fire boxes have been more than doubled. While the cost of boiler washing has been somewhat decreased as compared with the days before soda ash was used, the greatest saving has been in the better service and greater mileage of the engines, and the great reduction in boiler work, the boilermakers' pay roll showing a reduction of $75,000 per annum.

Boiler washing and blowing out being such an important factor when soda ash as the reagent is introduced into the tender, it may not be out of place to refer to what is considered good practice. There should be a sufficient number of blow-off cocks so distributed as to reach the centers of the greatest deposits of sediment. The principal blowing off should be done at the completion of the trip, and before the engine goes into the roundhouse. It should stand for a sufficient time for the mud to settle to within a few inches of the bottom of the boiler. In this way, with the loss of the least water, the greatest amount of sludge will be drawn off. In washing out, when the service will admit, it is beneficial to allow the boiler to cool down before letting out the water. When the time is short, this can be hastened by filling the boiler full and keeping it full by forcing water in as

fast as it runs out until cooled down to the desired temperature.

The report continues with the description of a series of tests made on the Chicago, Milwaukee & St. Paul Ry., to determine: (1) if by the application of soda ash, and with a sufficient number of blow-off cocks, and systematic blowing-off, a boiler could be run longer than without this care being taken; (2) what amount of alkali a boiler could carry, when there were no sludge conditions to assist, without causing foaming. The first test confirmed the efficiency of using soda ash and systematic blowing-off in keeping the boiler clean. The report gives the following conclusion as the result of the test for foaming:

> The general result of the test shows that if water in a hard-worked boiler is fairly free from sludge, the alkali must not rise above 160 to 170 grains per gallon, and for satisfactory work, should not rise above 140 grains. It is also shown that considerable amounts of alkali are carried out with the water lost from a foaming boiler, so that at the end of several hours' working the alkali present in the boiler is less than the total added.

In submitting these conclusions of the tests, Mr. H. E. Smith, chemist for the Chicago, Milwaukee & St. Paul Ry., presented the following general remarks concerning the nature of the impurities found in boiler-feed waters:

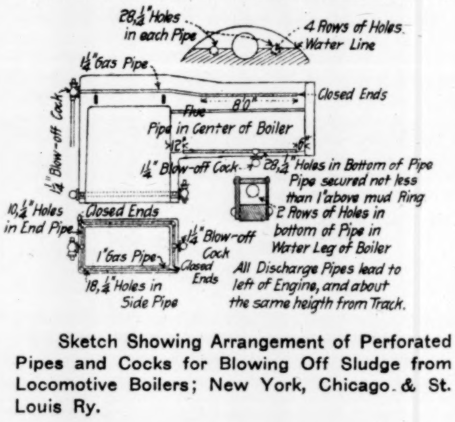
> The solids present in boiler waters may be divided into two classes, the incrustating and non-crustating solids. In the majority of boiler waters of the United States the incrusting solids consist largely of calcium and magnesium carbonates, and calcium sulphates. Under the action of the heat alone, the carbonates are precipitated at 212° F. and the sulphate at about 260° F. The sulphate is much more injurious than the carbonate, because it forms a much harder and denser incrustation. Occasionally magnesium sulphate or chloride is present. These two substances are soluble in water, but when heated under pressure, especially if in the presence of iron, are decomposed, magnesium hydroxide being precipitated as incrustation, while the acid is set free as a corrosive element. Silica, alumina and oxide of iron are generally present in small amounts and enter the incrustation.
>
> The non-incrusting solids are the compounds of the alkalies, and are usually made up of sodium and potassium sulphates, and sodium chloride. Sodium carbonate and potassium chloride are sometimes present. None of these compounds form incrustations, but, on the other hand, cause foaming if present in large amounts. Our experiments indicate that, other things being equal, the various alkali compounds are about equally efficient in producing foaming.
>
> In actual practice, however, the carbonates produce a flocculent sludge with waters containing calcium and magnesium compounds, and on this account are indirectly more efficient than sulphates or chlorides in producing foaming.
>
> Occasionally free mineral acid, generally sulphuric acid, is found in natural waters, and produces corrosion. Sewage, and some kinds of factory waste, produce both foaming and corrosion. Suspended solids obviously produce incrustation, and sometimes foaming. When waters are treated in the boiler with soda ash, the incrusting solids are changed to carbonates and precipitated as a soft sludge which is readily blown out, instead of coming down in crystalline condition and adhering to the surface of the boiler. Extended experience has shown that it is not necessary to use as large an amount of soda ash as the full chemical equivalent of the incrusting solids. This is of very decided advantage in boiler operation. There appear to be several reasons for this fact, as follows:
>
> 1. If no precipitant is used, all of the nominally incrusting solids do not immediately adhere to the boiler, but may be easily removed by blowing or washing.
>
> 2. When soda ash acts upon calcium and magnesium sulphates it is changed to sodium sulphate, which has no further action as a precipitant. But calcium and magnesium carbonates require for their precipitation only the absorption of the free carbonic acid gas of the water. This action leaves the soda ash in the form of bicarbonate, which, by the heat of the boiler, is gradually changed back to the normal carbonate (soda ash), which can then act upon a fresh portion of incrusting solids.
>
> 3. The flocculent sludge produced by the direct action of the soda ash doubtless incloses particles of crystalline solids which are thrown down by heat alone, thereby preventing them from adhering to the boiler.
>
> In calculating the amount of soda ash to be used, we employ the following table of ratios, which represents present average practice:

1 grain of the following salts per gallon of feed-water:	Requires per 1,000 gallons feed-water, following amounts of 58° soda ash.
Calcium or magnesium carbonate..	0.02 lb.
Calcium sulphate	0.10 "
Magnesium sulphate	0.13 "
Magnesium chloride	0.16 "

> The proper ratios to be employed vary somewhat according to the amount and character of the incrusting solids and the amount of alkalies in the waters. They also vary according to the service of boilers and the care used in blowing and washing out. The ratios given are suitable for the average waters of the Mississippi Valley, for boilers which receive reasonably good care. The proportion of the soda ash specified for carbonates is only about one-seventh of the chemical equivalent, That for calcium sulphate is nearly the full equivalent, while for magnesium sulphate and chloride the theroetical amount is used on account of the corrosive nature of the salts. Some waters contain originally some sodium carbonate, in which case less soda ash is needed, or it may be entirely dispensed with. This is the case with the Portage and Kilbourn City waters used in the tests. On account of foaming, it is not desirable to use more than 10 lbs. of soda ash per 100 miles, even if the calculation calls for more.

Treatment of Water at Pumping Stations.

Water purification at the pumping station where scale-making matter is present in large quantities is the method advocated by several members of the Association. They assert that no two waters, from different natural sources, are just alike, and the treatment should be varied to suit each particular case, which can only be done by the pumping-plant treatment. This method is by no means a new proposition. Lime, or combined lime and soda, have been used for more than fifty years, and is known as the Clarke or Clarke-Porter method of purification. Later, other reagents have entered the field. The experience of the Union Pacific Ry. with tri-sodium phosphates will, we believe, be of interest. Their report says:


28, ¼" Holes in each Pipe
4 Rows of Holes.
Water Line
1¼" Gas Pipe
Closed Ends
8'0"
Flue
Pipe in Center of Boiler
12"
6"
1¼" Blow-off Cock
1¼" Blow-off Cock
28, ¼" Holes in Bottom of Pipe
Pipe secured not less than 1" above mud Ring
10, ¼" Holes in End Pipe
Closed Ends
2 Rows of Holes in bottom of Pipe in Water Leg of Boiler
1¼" Blow-off Cock
1" Gas Pipe
Closed Ends
18, ¼" Holes in Side Pipe
All Discharge Pipes lead to left of Engine, and about the same heigth from Track.

Sketch Showing Arrangement of Perforated Pipes and Cocks for Blowing Off Sludge from Locomotive Boilers; New York, Chicago & St. Louis Ry.

> On Nebraska Division, between North Platte and Sydney, the water has a trace of sulphuric acid, which is very destructive to the flues and fire boxes. Before the use of tri-sodium phosphates the average mileage of flues was 30,000 in freight service and 35,000 in passenger; fire boxes, 30 months in freight and 36 months in passenger service. Our experiment was first made with two engines in the same condition. One was treated with tri-sodium compound—the other was not. The engine treated with compound cost $2.01 for boiler washing, against $15.41 on the other. The cost for boiler work on the engine using boiler compound was $2.81, against $22.09 for work on engine not using the compound. The results obtained on these two engines led to continuing the test six months. In place of depositing the compound in the locomotive tank, we arranged to pump the necessary amount into the station tanks for each one thousand gallons of water used. By this means all engines running on the division received the treated water. An agent of the company furnishing the compound remains in the district, instructing the pumpers and seeing that the necessary amount of compound is put into the tank.
>
> The test began September 12, 1898. A result of the six months' test as compared with the six months of previous year is shown in the following table:

Year	1897-8.	1898-9.
Engine mileage	362,756	517,007
Tri-sodium phosphate used: Pounds.	.....	2,937
Cost	.....	$1,791.56
Boilers: Washed—Number	1,241	421
Cost	$786.75	$330.78
Blown out—Number	.....	1,017
Cost	.....	$118.78
Boiler work reported: Number	1,120	493
Cost	$2,073.85	$1,083.94

Cost of boiler work and washing:	
1897-8. No tri-sodium phosphate used........	$2,860
1898-9. Using tri-sodium phosphate..........	1,533
Decreased	$1,327
Cost of tri-soda phosphate water purifier in 1898-9.	1,791
Inc. in expense. 1898-9 compared with 1897-8 (35%)	$464

> Increase in engine mileage for same periods, 42.5%.

Year.	Engine mileage.	Cost per 1,000 miles. Washing and blowing out.	Boiler work.	T.S.P.	Total.
1897-8....	362,756	$2.16	$5.72	.....	$7.88
1898-9....	517,007	.87	2.09	$3.47	6.43
Decrease.......		1.29	3.63	....	1.45
Per cent. of dec..		60%	63.5%	.....	18.4%
Net saving per 1,000 miles					$1.45
Net saving for six months.					749.65

> The cost of water purification with tri-sodium phosphate was thus, 4½ cents per 1,000 gallons, representing an actual saving on the division of $1,500 per annum.
>
> The first effect derived from the water purifier was the tightening of leaky flues and fire boxes of engines using it, and a consequent reduction in boiler work on those engines. Where boilers had been washed every other trip, and water changed the intermediate trip, they are now run from six to eight trips regularly to one washing, and one engine was run 30 days (4,860 miles) to one washing, , by simply blowing out three gages of water at the end of each trip. From Sept. 15 to Oct. 31, every available engine was pressed into service, and they were returned at terminals as soon as they could be made ready. During this period at least three more engines would have been necessary in the third district to have handled the business as promptly as it was handled had we not used the water purifier.
>
> The benefit of water purifier to flues has already been noticeable, whereas the average mileage between the changing of flues of Third District engines has been 28,100 miles. Engine 647 made 38,122 miles, and, when taken into shop, both flues and crown sheet were unusually free from scale. Engine 1813 made 47,538 miles, and when overhauled, January 13, 1899, the flues were found in such good condition that only a few (39) were removed—in the belly of the boiler—to facilitate inspection. This is the first time in over eight years that a Third District engine has been shopped for repairs on account of worn-out condition and not necessary to change all of the flues.
>
> Our chemist analyized the sediment obtained from a boiler in which water purifier had been used, and reports that the action of the compound (water purifier) precipitates the phosphates of lime and magnesia, and prevents the carbonates and sulphates from adhering to the boiler, and, so far as he can judge, from the form of the composition of the scale, the chemical seems very efficient.
>
> The water in the Third District is exceptionally bad for locomotive boilers. It has been necessary to remove fire boxes in engines in that district in two years and three years is a fair average of the life of a box in engines permanently located there. It is fair to presume, therefore, considering the reduction of boiler work on Third District engines, that we may expect the life of fire boxes and flues to be extended correspondingly.

> Two water stations—Arcadia and Townsend—on the N. Y. C. & St. L. Railroad are now being treated by the combined lime and soda treatments. The chemicals are handled by the man who does the pumping, and it is estimated the additional work costs the company nothing, as the man would have to be paid whether the water was treated or not. The lime-and-soda ash is made in solution by the pumper, and is fed gradually as the water is pumped into the auxiliary tank, a prescribed amount to 1,000 gallons; after being allowed from 12 to 20 hours to settle, it is pumped into the service tank, from which it is delivered to the engines. To treat the water at Arcadia, soda ash and lime water are used; 55 gallons of saturated lime water and 3 lbs. of soda ash to 1,000 gallons of water. At Townsend, 80 gallons of saturated lime water and 2 lbs. of soda ash per 1,000 gallons of water are used.
>
> The following is an analysis of the water treated:

	Grains per U. S. gallon. Total solids.	Lime as sulphates.	Alkali, aluminum and iron.	Magnesia.
Arcadia......	106.40	23.38	0.29	5.04
Townsend....	35.39	5.03	0.52	1.99

> The cost at Arcadia for reagents is 3½ cts. per 1,000 gallons; at Townsend, 2½ cts. The auxiliary tanks have to be cleaned frequently to relieve them of impurities. The water at Arcadia, before treatment, was of such a nature as to give constant annoyance with leaky flues and fire boxes. It is now satisfactory. The alkali left in the water causes no trouble that cannot be entirely taken care of with the surface and blow-off cocks. The accompanying sketch shows the arrangement of surface and blow-off cocks used on the engines.

The report refers briefly to the use of feed-water heaters, with the remark that in some kinds of water they are reasonably effective. It suggests the possibilities of benefit in the case of turbid waters of using mechanical filters for clarification. Distillation is classed as too costly to be taken into consideration. In conclusion the committee summarizes the results of its investigation as follows:

> The first effort in preventing trouble in boilers from water impurities should be in searching out sources of supply furnishing the best obtainable feed waters.
>
> (1.) In building a water station where, by a larger first outlay, water of a better quality (that is, costing less for purification) may be obtained, the question should be carefully considered before accepting the poorer water in order to save first cost of plant. The treatment of water is expensive, and the cost will pay the interest on a large investment. For example, in a station furnishing 100,000 gallons of water in 24 hours, which costs 4½ cts. per 1,000 gallons for purification, were it possible to substitute a supply costing but 2¼ cts. per 1,000 gallons for treatment, an outlay of $16,425 would be warranted in order to bring about the change. The annual cost for purifying the 4½-ct. water would be $1,642.50; for the 2¼-ct., $821.25; the difference in the cost for the two treatments being $821.25, which equals 5% on an investment of $16,425.
>
> (2.) Where necessity compels the use of troublesome water there are few cases where by treatment, either mechanically or chemically, fairly good waters for boilers may not be obtained, the important consideration being the method employed. There are in the market numerous so-called water purifiers, purges, oils and boiler-

cleaners, many of them absolutely worthless, others dangerous. It should be a rule never to allow the use of any compound for this purpose until its effects and dangers are fully understood.

(3.) The cost of purifying waters will always be cheap when compared with the use of waters which cause trouble in the boiler. The best methods to be employed can only be determined when the conditions are fully understood. The cost for water purification depends on the character of the water and the methods and reagents employed. Lime and soda ash are the cheapest of the effective nad harmless reagents for this purpose, and direct treatment in the tender is the least costly method. Waters carrying 25 grains of incrusting matter per gallon, 5 of which are sulphates, may be successfully treated with soda ash at a cost of about 40 cts. per 1,000 miles of engine mileage, or about 6.12 mills per 1,000 gallons of water. With engines equipped with blow-off cocks of sufficient number and correctly located, and with 4% of the water taken blown out; in keeping boiler free from sludge, the engine may be safely and satisfactorily run from 2,000 to 3,000 miles between washouts.

Assuming the cost for untreated water to be 10 cts. per 1,000 gallons, the 4% wasted in blowing out would represent a value of 4 mills per 1,000 gallons, or a total for treatment and waste of 10.12 mills. In this calculation no account is taken of the heat losses in the water blown out, and if the blowing out be done at the end of the trip, when the engine goes into the roundhouse for a layover, it should not be. But if on the road, a further cost equal to the value of the heat in the water wasted should be added to the other expenses for water purification. In waters of the character and treated by the methods just referred to, the results that may be expected from engines in freight service is that 100,000 to 200,000 miles may be made between changes of flues, and that the life of fire boxes will be from eight to fifteen years.

Water with 40 grains of incrusting matter, seven or eight of which are sulphates, may be treated in the same manner with fairly good results, but with an additional cost for reagents and blowing out in proportion to the increase in incrusting matter and sulphate.

Treatment of water in the station tank, as represented by the several cases already alluded to, costs for reagents from 2¼ to 4½ cts. per 1,000 gallons, and we estimate the loss of water in cleaning the settling tank, and in blowing out to keep the concentration of alkali to a safe limit, to be as great as by the direct method. The first cost for the water station is greater and will be further increased by the introduction of automatic devices for delivering the reagents. On the other hand, the special advantages are that the treatment may be varied to suit each particular condition of water; also that the water feed from sludge will carry a greater concentration of alkali without trouble from foaming.

The cost for treatment of water by mechanical purifiers or cleaners is for the water and heat lost in blowing out. The blow-off cock is the active agent for purification in all mechanical cleaners; the part performed by the remainder of the devices is to assist in bringing mud within its reach. When waters contain little or no suljhates, or where alkali is troublesome or earthly matter is in suspension, they may be successfully handled by mechanical devices. We do not consider it safe practice, where sulphates are to be dealt with, to depend upon mechanical devices, except they be reinforced by chemical reagents for neutralizing the incrusting matter. The cost for clarification of water by filtering or settling is for first cost of plant, the interest and maintenance of same. By the unaided method, the only other expense should be for attendant and water used in cleaning. With the mechanical filter, the water used for this purpose should not exceed 5° of the amount pumped, and the time consumed in cleaning should be about 15 to 20 minutes every five to ten hours. Where coagulants are used, there will be an additional cost for chemicals of 1 to 2 cts. per 1,000 gallons of water clarified.

(4.) There should be on the staff of the Superintendent of Motive Power, where the size of the system will warrant, and boiler feed waters are troublesome, two specialists; one a boiler washing inspector, who has charge of the boiler washing. In the performance of his duties, he should as often as possible visit the different roundhouses and shops to see that they are equipped with and using the tools intended for this purpose; that the boiler washers understand how, and are doing good boiler washing; where soda ash put in the tender is the reagent and method employed for purification, to see that the correct amount is properly put in, observe the manner in which the blowing off is done, and to stay at each point until a personal inspection has been made of all boilers cared for by them.

The other specialist should be an assistant to the chemist, and should have a knowledge of the chemistry of water, and a good understanding of geology; the water supply of the system, so far as relating to quality, to be directed by him. Among his duties to be the searching for, and locating, the best sources of water, looking after the condition of water in existing stations, and where any falling off in quality develops, to determine cause. The analysis records, and reports in relation to water purification and supply, and its performance in the boilers, to be under his charge. He should spend a part of his time on the road personally inspecting pumping and purifying plants and methods, and should keep in close touch with the boiler washing inspector, roundhouses and shops. A man of this character, with a correct understanding and well directed efforts, would make himself useful in that department, and be the means of materially lessening trouble in boilers from water impurities.

ANNUAL CONVENTION OF THE AMERICAN RAILWAY MASTER MECHANICS' ASSOCIATION.

(Concluded from page 402.)

Tuesday's Session.

The second day's work of the convention was opened by a short talk by Capt. Robley D. Evans, U. S. N., after which the regular business of reading and discussing the special committee reports, which was begun the day before, was resumed. The first report was that of the Committee on the Purification of Boiler Water, which is abstracted elsewhere in this issue.

Discussion.—The discussion showed that there was much difference of opinion as to relative value of various methods of feed-water purification. Mr. F. A. Lelano (C., B. & Q.) called attention to the practice common abroad of heating the boiler feed-water by exhaust steam, and thus, by raising the temperature, precipitate the lime salts which caused scaling. In respect to this method, Prof. H. Wade Hibbard called attention to the dangers of making the feed-water oily by the oil from the exhaust steam providing the steam was injected directly into the water. He pointed out that a considerable more resistance was offered to the passage of heat by a deposit of oily sludge than by a deposit of ordinary scale or deposits not containing oil. Mr. J. N. Barr (C., M. & St. P.) considered that while experience had shown that various different methods of feed-water purification were good, it had also been shown that to get good results from any of them they must be followed out thoroughly and properly. The thing which above all was necessary was to discipline and train the employees to handle properly the methods of feed-water purification put into their hands for operation. Mr. John Mackenzie (N. Y., C. & St. L.) spoke highly in favor of the use of blow-off cocks arranged according to a special plan which was fully described in the committee report.

Cast-Iron and Steel-Tired Wheels for Locomotive and Passenger Car Service.

The committee reported that it was able to obtain comparative records of cast-iron and steel-tired wheel service from only two roads, viz.: The Lake Shore & Michigan Southern, and the Chicago, Milwaukee & St. Paul. It embodied these records in tabular form in its report. Briefly stated these records showed too great a discrepancy to permit reliable conclusions to be drawn from them. In respect to breakages, the L. S. & M. S. Ry. statistics were very much in favor of steel-tired wheels, while those of the C., M. & St. P. Ry. were equally strong in favor of cast-iron wheels. In respect to cost, the statements of the two companies were as follows:

Comparative Cost of Service, per 1,000 Miles of Steel and Cast-Iron Wheels.

					All scraped.	
Kind of wheel.	Class of service.	Cost, new.	Value of scrap.	Net cost.	Mileage in thousands.	Cost, 1,000 miles in cts.
Lake Shore & Michigan Southern Ry.						
33-in. c.-i.	Passenger	$6.85	$2.62	$4.23	....	9.40
33-in. "	Locomotive	6.75	4.21	2.54	62	4.10
30-in. "	"	5.75	4.14	1.61	73	2.21
28-in. "	"	5.35	3.55	1.80	..	2.77
42-in. steel	Passenger	67.32	5.00	....	..	11.98
36-in. "	"	50.63	5.00	....	..	9.71
33-in. "	Locomotive	54.00	5.00	49.00	328	15.25
Chicago, Milwaukee & St. Paul Ry.						
33-in. c.-i.	Passenger	$5.50	$3.00	$2.50	89	2.81
33-in. "	Locomotive	5.50	3.00	2.50	80	3.13
30-in. "	"	5.13	2.80	2.33	81 75	2.89 3.11
28-in. "	"	4.75	2.59	2.16	59	3.66
42-in. steel	Passenger	51.00	5.00	46.00	471	9.77
38-in. "	"	47.00	5.00	42.00	422	9.95
33-in. "	"	41.00	5.00	36.00	327	11.04

For passenger service the discrepancy exhibited by this table was decided, partly due to difference in average mileage and partly to difference in relative value of new wheels and scrap. For locomotive truck wheels the two reports agreed much more closely. In conclusion the committee reported that: (1.) It was not able to decide from the facts presented whether steel-tired wheels were safer than cast-iron wheels, except in case of engine trucks. (2.) For engine trucks it would recommend steel-tired wheels from considerations of safety. (3.) Cast-iron wheel service was cheaper than that obtained from steel-tired wheels.

Discussion.—Upon vote of the convention the committee, with two additional members to be appointed later, was ordered to be continued to investigate its subject further, and also to investigate the question of cast-iron wheels for locomotive tenders, including the distribution of the metal in the hub, plate and tread.

Advantages of the Ton-Mile Basis for Motive Power Statistics.

The committee reported that while very few railways were using the ton-mile basis for keeping their records of locomotive performance, the companies from which they had heard were almost unanimous in expressing the belief that the ton-mile basis was the most desirable unit for that purpose. The report then presented quite a lengthy argument to show the advantages of the ton-mile basis, which we do not give as it was largely a threshing over of matter already familiar to those who have studied the subject. After a brief discussion the committee report on stay bolts was read.

Wednesday's Session.

The first report taken up was that of the Committee on the Best Method of Applying Stay Bolts to Locomotive Boilers. This report is fully abstracted elsewhere in this issue, and only such parts of the discussion as are of most general interest will be given here.

Discussion.—Referring to a statement in the report, Mr. S. Higgins (Lehigh Valley) stated that there was another reason than those given for drilling instead of punching the detector holes. He had found by experiments made on a machine, rigged up to give a vibrating test, that the amount of vibration required to break a drilled bolt was much greater than that required to break a punched bolt. Mr. R. H. Soule (Baldwin Locomotive Works) spoke of the advantages of drilling the hole in the shop instead of in place, and Mr. F. Slater (Chic. & N.-W.) also urged that drilling the bolts after they were in place was unsatisfactory for the reason that it was hardly ever possible to get the hole in the center of the bolt or parallel with the axis of the bolt. Mr. A. E. Manchester (C., M. & St. P.) expressed a doubt of there being any great value in the detector hole. He detected perhaps one broken staybolt a year by this method, but not many more. Mr. Robert Miller (Mich. Cent.) stated that his experience was directly contrary to Mr. Manchester's.

The next report on the desirability of using flanged tires on all drivers of mogul, ten-wheel and consolidation engines was abstracted in our last issue. The discussion partook of the nature of an experience meeting, and the bulk of the testimony was in favor of having all wheels with flanged tires. The following report on the use of nickel-steel in locomotive construction was merely a bibliography of articles and books on nickel-steel and contributed very little new information. The report on standard pipe fittings, which came next, outlined briefly the investigation of the committee and recommended that the Briggs standard be adopted and used. The discussion on this and the preceding report was very short and added little information to the subjects. The final report was that of the committee appointed to suggest subjects for committee reports at the convention to be held in 1900.

Subjects for the 1900 Convention.

The report recommended the following subjects:

(1.) The proper relation between diameter and stroke of cylinders in various types of locomotives for various classes of service.

(2.) Maximum ratio between tractive force and weight available for adhesion in various types of locomotives and for various classes of service.

(3.) Latest type of piston valves. Their economy in repairs on the locomotives and difference in cost of repairs to valves.

(4.) How to test lubricating oils and various bearing metals in regard to wear of journals and cylinders.

(5.) The relative economy and efficiency of hydraulic versus pneumatic riveting for boilers.

(6.) Relative cost of power transmission by shafting versus electricity.

(7.) Best type of stationary boilers for shop purposes, with reference to different kinds of coal and water.

(8.) Superheated steam and its economy for use in stationary engines, and is it practicable to arrange similar apparatus for locomotive service?

(9.) Present status of compound locomotives, and what is the best ratio of cylinders for various classes of locomotives and service.

Closing Business.

The election of officers for the coming year resulted in the choice of the following: President, J. H. McConnell, Union Pacific Ry., Omaha, Neb.; First Vice-President, W. S. Morris, Chesapeake & Ohio Ry., Richmond, Va.; Second Vice-President, A. M. Waitt, New York Central & Hudson River R. R., New York city; Third Vice-President, J. N. Barr, Chicago, Milwaukee & St. Paul Ry., Milwaukee, Wis.; Treasurer, G. W. West, New York, Ontario & Western R. R., Middletown, N. Y. After some further routine business the convention adjourned.

Noon Hour Discussions.

The noon hours of the three sessions of the convention were devoted to short discussions on topical questions, and such parts of these discussions as are of most general interest are given here.

Air-Brake Instruction.—This question in full was: Has not the time arrived when air-brake instructors can accomplish more by instructing those who maintain brakes how to maintain them, than to instruct those who use them how to use them? The discussion was carried on by Messrs. J. F. Deems (C., B. & Q.), J. L. Lawrence (Cumb. Val.), R. H. Johnson (A. & W. P.), and by Messrs. Huntly and Conger, air-brake instructors. Mr. Lawrence questioned the value of instructing the men who maintained air-brakes until the railways employed men of higher intelligence for this work. The other gentlemen all advocated the instruction of the men who maintain the brakes, but deprecated any discontinuance of the instruction of the engine-drivers in the meantime. Speaking on the question, Mr. Conger, one of the air-brake instructors, called upon to speak, said:

> I have found that the question of air-brake maintenance has been left until the last thing, and one of the greatest difficulties we have in instructing the enginemen, is to get them to do good braking with poor material. As an instance of how poor material can be, I was on a mountain road some two or three weeks ago with some air-brake men who were testing the matter of controlling trains down heavy grades with the assistance of hand brakes. A careful canvass of the brakes was made, and we found about 40% of the brakes on a train of 28 cars could be classed as being in good order. What was the matter with the other 60%? There are so many things going wrong with the air-brake equipment which can be easily attended to by the car repairers on very short notice, if they only knew just where to look for it, that it seems surprising to the air-brake instructors sometimes that more attention is not paid to it, and I think it looks like the sunrise of air-brake perfection when we find that the Master Mechanics' Association is commencing nearer to the bottom, by instructing the men who have charge of the air-brake to inspect it as they inspect the rest of the car. In my experience with air-brake matters, I have found that a car repairer is as easily instructed as the most intelligent engineman, and they certainly get a great deal better service out of the brake for the amount of skill they possess than is the case with the higher

grades; and I speak as an engineman, for that is my profession.

As a result of the discussion, Mr. H. J. Small (So. Pac.) moved that it was the sense of the convention that the time had not arrived when we could abandon the instruction of those who used the brakes; but that it was very proper that more care should be given to the maintenance of brakes than had been done heretofore. The motion was carried by vote.

Metal Couplings.—The question in full was: The comparative efficiency and economy of metal flexible joints and rubber hose for steam heating connections. The discussion was opened by Mr. A. W. Gibbs (P. R. R.), who said in part:

I have taken the trouble to avail myself of some records of metal flexible joints, which we began to use about 1892. At that time the maintenance of connections between our engines and tenders became troublesome on account of the oil which was thrown from the driving wheels. It gave us a great deal of trouble by destroying various kinds of flexible hose which were not adapted to resist the action of oil and heat; and we finally went into the use of a flexible metallic joint, which we now use wherever we have to convey steam between engines and tenders. I find that since 1893 we have bought about 2,900 joints, for 750 engines altogether, equipped on all lines, in which there appear to have been about 25 failures from various causes, and they are now used entirely for the purpose mentioned, partly because they resist the action of oil, which destroys other material, partly because there is no possibility of bursting, which is very awkward on a through train where you cannot afford to stop, and partly because, owing to our steam heating system, we have to carry very heavy pressure between the engine and tender, in order to operate a vacuum pump. Ordinarily you do not have to carry much more than 40 lbs., unless you are running a dynamo in the baggage car; but we are practically running a separate engine all the time on our passenger trains, because we have a vacuum pump in our tender. I can only say that we have used this number of Moran joints and appear to have a little over two dozen failures since 1893. I have not very much to say, except that while we recognize that the first cost is much greater, at the same time there are places where you cannot afford to have a failure even at the expense of greater first cost; that is, you can afford to pay a considerable amount to avoid failures in certain important places. I cannot say anything about this joint in other places between cars. I know nothing of that. After mentioning the good points, I would say that the principal trouble so far has been that when the joint is not in use, when you do not have steam pressure on the pipe system, it is injured by dust and by rattling. The remedies are either to keep the pressure on all the time, or else disconnect the joint in the summer when you are not using any steam.

Mr. F. Slater (Chic. & N.-W.) also spoke favorably of the Moran joint for the steam pipe connection between the engine and tender, but urged the importance of locating the pipe directly in line with the draw bar, since when it was placed to one side the joint wore very rapidly because of the motion caused by rounding curves, etc. Mr. A. E. Manchester (C. M. & St. P.) said:

We commenced last fall applying the Moran joint to a number of our passenger engines that haul dynamo trains. We had been experiencing a great deal of trouble with those connections with the high pressure steam and the excessive motion with our overhead system between engine and tender. The experience thus far has been entirely satisfactory with the Moran joint. We have had no failures whatever, and there has been no cases of leakage. We are putting on some more of the joints at the present time in this same class of service. The question of cost is considerable when compared with the hose connection, but after looking over our record of cost to maintain the hose connections, we came to the conclusion it would be a very good investment. We found that in that particular class of service of dynamo trains, we were using about seven or eight hose a year, to maintain the service between the engine and tender, with occasional delays occurring on the road by the failure of the steam; and we believe that, so far as we have gone at least, the Moran joints are very satisfactory. The joints come recommended in such a way that we get a three years' guarantee on them, which of itself is something of an object.

Extended Piston Rods.—This question in full was: "What advantages are gained by the use of piston rods extended through the front cylinder head?" The discussion was opened by Mr. R. H. Soule (Baldwin Locomotive Works), who said:

This question of the benefits, if any, following the introduction of extended piston rods or tail rods, as they are often called, is one of those questions which is now coming to the front as one of the natural sequences of the great increase in the size of our locomotives; the diameter and stroke of the cylinder having been increased greatly within recent years, and the boiler pressure as well. In canvassing this question among the members present, I find that there is little fixed opinion on the subject among the railway men, and no unanimity of opinion among the locomotive builders. I know of one road, the New York Central, which makes it a rule that all cylinders, 19 ins. and upwards in diameter, shall have their piston rods carried through the front ends. I heard from a locomotive builder that in their own family they do not consider it necessary to apply the piston rod extension unless the cylinder is 28 ins. in diameter or upwards, so that you see at once there is a wide difference of opinion on this subject. As regards the mechanism by which the piston rod extension shall be supported in cases where it passes through the front end, there is no settled practice. It seems to be difficult to get a bushing or support more than 5 ins. in length if you insist on having the piston rod extension in the bushing at all times. If you are willing to have the piston rod extension draw nearly out of the bushing on the back stroke, you can increase the bushing to 9 ins. When these extensions were first introduced into service, they did not carry a good service record, because in the early cases they were not lubricated. The question of lubrication comes up, and one locomotive builder states it to be their practice, where they apply extension, to always apply a triple sight-feed lubricator. One branch goes to each steam chest and the third goes to the bushing on the front end of the low pressure cylinder, for the lubrication of the piston rod extension. Another locomotive builder states this to be unnecessary, and that the successful lubrication of this piston rod extension only requires some nice work in the arrangement of lubricating grooves in the bushing, so that the steam which is supposed to be supplied with its own lubricant can reach the bearings in question. Among the locomotive builders it is felt that the piston rod extension in some approved form, when the practice has reached a final stage, where it commends itself to the railroads, will be a necessary feature in all powerful locomotives; but there are a number of details to be worked out, and I do not think it can be said yet that any device which has been put out is an absolute success.

Mr. J. E. Sague (Schenectady Locomotive Works)stated that he had had some experience with extended piston rods on compound locomotives. The company's first bearing was a brass bushing 5 ins. long, but the wear was found to be excessive and they now used bushings 9 ins. or 10 ins. long. They employed an auxiliary sight-feed cup where the extended piston rod was used, but they did not feel that this was by any means an absolute necessity.

Mr. A. L. Humphrey (Colo. Mid.) considered that the extended piston rod had got beyond the experimental stage. On his road he knew that with engines having 20-in. cylinders and 21-in. cylinders, which sometimes drifted 100 miles at a stretch, it was necessary to have extended rods in order to keep the cylinders from excessive wear. He used engines carrying 180 lbs. steam pressure and no lubrication was employed except the ordinary cylinder lubrication. Care was taken to keep the bushings accurate and to this end they were turned every 60 days.

Mr. F. Slater (Chic. & N.-W.) had found that the cylinder wear was at the top and not at the bottom and hardly thought that that extended rod could be of any advantage in such cases.

Mr. F. F. Gaines (L. V.) had not found any excessive wear in 30-in. cylinders and questioned the need of any device like the extended piston to prevent wear.

Mr. C. H. Quereau (D. & R. G.) said:

The road with which I am connected has a number of locomotives with the extended piston rods; but it is true that our engines are drifting half the time. The first district of the first division is 120 miles long, up grade for 58 miles and down grade for 62 miles going west; and going east the reverse is true. I have looked somewhat into this matter of the extended piston rod, and agree with what Mr. Soule has said. I believe, however, a perfected device for the extended piston rod is nearer at hand than Mr. Soule indicated. In the first design we had, the bearing of the piston rod was only 3 ins. We now have in service a design in which the bearing is 8½ ins. and adjusted perpendicularly, so that as the piston rod wears we can raise the piston to the center of the cylinder. I think that the best device along this line is in use on the Santa Fe road, in which they have a long bearing similar to the one I have just mentioned, and just ahead of that they have a packing gland, a metallic packing like the Jerome or any other used on the regular piston head. One difficulty we find with ours, which is simply a brass bearing and a sleeve over the extension piston rod, is in the matter of lubrication. We have on most of the engines a lubricating cup, a cup in which the oil is placed the same as on the lubricator itself, except that there is no sight feed. It will hold possibly a quarter of a pint; and we find the first time the locomotive throttle is closed the oil is drained out of this lubricator cup. With the device used by the Santa Fe road they have a perfect means of lubrication as much as you have on the piston rods at the back ends of the piston. In the circumstances under which we are operating I believe the extended piston rod will be a valuable feature, and with the packing on the extended rod, the same as on the piston rod, I see no reason why piston wear cannot be reduced both on the piston rod and on the bearing.

A number of others also spoke in favor of the extended piston, including Mr. Jos. Cockfield (Chic. & N. W.) and Mr. T. R. Browne (Pa. R. R.) The latter gentleman said:

I do not think it necessary to have the extended rod on an ordinary sized cylinder. We had an engine with 24-in. cylinders, solid heads, with a lining of block tin around the head. After awhile they wore away and the crosshead began to show trouble. The crosshead also had block tin on top and bottom of the wearing surfaces between the guides and the front end of the crosshead, and it would wear on the bottom of the back and on the top of the front end, and after the engine was running a little while it looked as if the guides were out of line. The piston wore at the bottom and the crosshead went down with it. We took the crosshead out occasionally and relined it and put it in again in good condition, and we turned the piston around to let it wear on the other side but the same trouble would take place. Finally, we decided to put an extension rod on, and after we did so there was no further trouble. We demonstrated on the 24-in. piston that the extended rod was a benefit. It was a low-pressure cylinder and consequently we could put a gland on the front of the cylinder head and it lasted a long while without replacing. We did not go to any expense in making a covering for it any more than a piece of gaspipe to slip over the gland to prevent any dirt getting in it. If we have any means of regulating the piston or bringing it up centrally, I think it is a benefit.

* * *

THE AMERICAN ISTHMUS SHIP CANAL CO. is the name of a proposed company, the object of which is said to be to acquire existing or future rights to build a canal across the American Isthmus and to build a canal by one of those routes. Mr. Roger H. Lyon, 170 Broadway, New York city, is the attorney of the proposed incorporators, the real capitalists in the case being conveniently kept in the background.

THE PRESERVATION OF RAILWAY TIES BY ZINC CHLORIDE.*

By Walter W. Curtis, M. Am. Soc. C. E.†

Since the report made to the Society by its Committee in 1885, there has been but little published on the subject, and that has been in pamphlet form, making it extremely difficult to secure recent and accurate data on the subject. Probably many will be surprised to learn that during the last 12 years something like 10,000,000 cross-ties have been thus treated, and that during the present year there will probably be 1,500,000 ties treated.

It is difficult to learn much about the history of the ties on American railways. A rail carries with it the name of its maker, the year made and a guaranteed life. The tie is simply a stick, looking much like any other, with no marks on it and no record anywhere. The officials know that the first ties were originally laid during a certain year; that perhaps these were largely replaced when new rails were put down at a later date; that some have been renewed each year since; and generally that is all that can be accurately stated. Some roads can do more, and can tell how many ties have been replaced on each section each year; but if an attempt is made to ascertain the average life of a certain kind of tie, or of all kinds in the main track, it will almost invariably result in disappointment.

With certain woods durability can be secured by mechanical means for preventing the breaking down of the fibers under the rail, as by tie-plates. This is especially true of cedar, cypress and redwood. Woods which are of such texture that they resist decay and mechanical injury equally well for considerable periods, and have consequently been the most satisfactory timber for ties, are unfortunately few; being the white, burr, chestnut, post and rock oaks. With most of the American woods, however, nothing will materially prolong the life of the tie which does not essentially change the condition of the sap. Such change may in itself be sufficient to make a timber perfectly adapted for use as a tie; or it may still be necessary to protect it from mechanical injury; the determining factors being the character of the timber operated on or the process used.

The oaks which have been in the past and still are in some localities the principal source of the best ties are rapidly being exhausted. It is an especially favored road that can to-day secure any considerable supply of good white or burr oak from its own territory, and even then it is the policy to use the oak for but a part of the supply, supplementing it with other and less desirable materials. The cedar is being more largely used with and without tie-plates, but any largely increased demand for cedar, due to its adoption generally, would probably cause a rapid increase in cost. It is not a wood that is generally or uniformly distributed throughout the country; and even in Chicago, closely adjacent to the cedar supplies, the increased demand of the last 3 years has advanced the price from 25 cts. to 38 cts.

The future supply of ties must undoubtedly come from what are now considered the second-class or even waste woods. These, after chemical treatment, will resist decay for from 10 to 12 years, and will generally cost less than the white or burr oaks.

It is believed that the supply of ties will very shortly have to come from the inferior grades of timber, with a corresponding large increase in the number of annual tie renewals, unless it is possible to so treat them at a low cost as to give them a life equal or superior to that now secured from the oaks.

In the "Organ of the Progress of Railroads," series 1897, published in Wiesbaden, there is a table in which the average duration of various ties on the German railways is given for the zinc treatment and also for creosoting:

Oak,	zinc chloride,	15	years;	creosoted,	24	years.
Beech,	"	9	"	"	30	"
Pine,	"	12	"	"	20	"

At the time of the report to the Society, in 1885, three plants treating timber with zinc chloride were in operation in the United States, each working with a different process; the difference being in the methods adopted to prevent the impairment of the preservative treatment by the washing out of the zinc salt, which is quite soluble in water. This solubility of the chloride is the only objection to its use, but the exact value of this point is not determined to the author's satisfaction.* However, various methods have been devised to eliminate any objection on this score, and each of the plants in operation in 1885 was working on patented ideas, with this object in view. These included the Thilmany, the zinc-gypsum and the Wellhouse processes, only the latter of which is now in use.

---

*Abstract of a paper presented at the meeting of the American Society of Civil Engineers, on May 17. The paper is so lengthy that we can only abstract its main features, omitting the interesting particulars of experience on different railways. The author shows, however, that reports of such experience are frequently unreliable, owing to the utter lack of systematic record of the tie renewals on American railways.

†549 Marquette Building, Chicago, Ill.

*In Tratman's "Railway Track and Track Work" it is stated that the Southern Pacific Ry. uses the simple burnettizing process, as the ties are used in well-drained ballast and in dry country, so that there is no trouble from washing out of the preservative. Hence it was concluded that the extra expense for supplementary treatment would not be warranted under these conditions.—Ed.

The Wellhouse or zinc-tannin process consisted of the injection of a solution of zinc chloride containing a small amount of glue, followed by another injection of a solution of tannin, the effect of the tannin, it was claimed, being to form with the glue small particles of artificial leather, insoluble in water, which would plug up the ducts and retain the zinc chloride. A plant was in operation in St. Louis under the management of Mr. J. P. Card. The first timber treated was in 1879.

The first road to adopt the use of the treated ties, other than as an experiment, was the Atchison, Topeka & Santa Fe Ry., of which A. A. Robinson, M. Am. Soc. C. E., was then Chief Engineer. This road, in 1885, had a plant built, under Mr. J. P. Card's direction, at Las Vegas, N. Mex., consisting of two retorts 6 ft. in diameter and 106 ft. long, which operated on mountain pine. The Wellhouse or zinc-tannin process was used, except from 1889 to 1893, when the burnettizing method was followed. The number of ties treated in the 13 years, 1889-1893, was 2,909,269. The officials of the road express themselves as satisfied with the value of the treatment, but are discussing the relative values of the zinc-tannin and the plain zinc-chloride methods. The additional cost to inject the glue and tannin amounts to several cents per tie; and they are in doubt from their own experience whether the increased cost results in an increased life, and, if so, to what extent.

The plant at Chicago, Ill., is the successor of the original St. Louis plant, and was built in 1886 by Mr. Card and Mr. Chanute, operating under the name of the Chicago Tie Preserving Co. It consists of four retorts, and has treated, up to Dec. 31, 1898, 4,007,946 hemlock and tamarack ties for the Chicago, Rock Island & Pacific Ry., besides small lots for other parties. The usual methods of the Wellhouse process were followed until 1896, when a modification was introduced, consisting of the omission of the glue from the zinc chloride solution and the subsequent injection of the glue separately, followed by a third injection of the tannin.

This change was based upon experiments, and the idea that the admixture of glue with the chloride solution lessened its fluidity and consequently increased the difficulty of securing the injection of the desired amount of the chloride. It might also be argued that the province of the glue being with the tannin simply to plug up the ducts to prevent the washing out of the zinc, the only proper place for it is at the ends of the ducts and medullary rays; and that it is unwise to introduce into the body of a tie perishable organic material, like glue, to increase the duty of the chloride, and where it is practically impossible to force the tannin to it, by a subsequent injection. This modification, by necessitating three injections in place of two, somewhat increases the expense of the treatment, and while it is undoubtedly an improvement, the period of its use has been too short to demonstrate it, in increased life. The best evidence of its value is in the increased absorption of chloride obtainable.

The life of the treated ties on the C. R. I. & P. Ry. has undoubtedly been less than is readily obtainable by a more rational practice than was the custom prior to 1895. Until then the Chicago Tie Preserving Co. treated all ties sent to it, regardless of their condition as to moisture or soundness. Since 1895 this has been changed, and the ties are reinspected, when received at the works, by the company's men, and if not sound are condemned and turned back to the tie contractor. If the ties are too wet for treatment, they are piled up until sufficiently dry to take the proper amount of chloride.

In 1890 this company treated some experimental ties for the Duluth & Iron Range Ry. These consisted of 85 ties of white pine, 85 tamarack and 86 Norway pine. They were cut during the winter of 1889-90, treated in October, 1890, and placed in track very soon after, together with 10 Norway pine, 10 white pine and 10 tamarack untreated ties, which were cut at the same time and off the same land as those subjected to treatment. In 1898 it was found that the treatment had not only prevented decay, but had made the wood denser, thus materially reducing the cutting under the rail. It was estimated that the ties were good for 15 years more, and would have been good for a longer time had tie-plates been used, as the destruction of the ties will be from wear and not from decay. The untreated ties have reached the end of their career. They were a fair average of the untreated ties on the line, the effective life being between 7 and 8 years.

In 1891, 200 tamarack and 200 hemlock ties were treated for, and placed in the tracks of, the Pittsburg, Fort Wayne & Chicago Ry. Mr. Thomas Rodd, M. Am. Soc. C. E., Chief Engineer, said of them, in 1898, that for about 3 years they cut rather more than an oak tie. After that, however, they seemed to cut less than oak, and are still in good shape in main track. In 1896 and 1897 the same road put in track about 50,000 hemlock preserved ties; and during 1898 there have been treated for it 13,000 beech and 11,000 black and red oaks. The Maintenance of Way Committee of the Association of Transportation Officers of the Pennsylvania Lines made a full report on the subject of ties 2 or 3 years ago, in which it was recommended that 100,000 ties, preserved with zinc chloride, should be laid each year on their lines.

The profession and the railway owe a debt to Mr. J. Kruttschnitt, General Manager of the Southern Pacific Co., for the very careful and complete manner in which he has kept the records of the ties treated and used on his road. His is the only company which can furnish complete data on the subject; and when the labor entailed is considered, especially after preliminary tests have indicated the success of the treatment, so that there is some confidence in it, it is the more remarkable that he has so consistently and constantly devoted so much of his own time to it, as is necessary to insure its continuance. There can be no question of the value of these records to the railroad, and the slight expense is thoroughly justified, and would be, even if much greater than it is.

One of the difficulties in connection with the treatment of ties in the United States in the near future is likely to be this one of proper records. Treated ties, like the untreated ones, will show great, and, to the casual or superficial observer, entirely unaccountable, variations in life; and, unless it is possible to determine definitely by total averages the life secured from the ties, there are apt to be periods when those in authority will conclude—from impressions, not records—that treatment is a failure and a waste of money. Even under favorable conditions, ties will develop eccentricities which will demand investigation and expert consideration, if the best results are to be obtained. This has been the case already in several instances in the United States and abroad, and as more roads adopt the process and attempt to let it run itself, failures are bound to occur, without the records, which, if properly kept, would indicate the cause and permit the remedy to be applied.

All the treated ties on the Southern Pacific Ry., except the bridge ties, which are creosoted, are preserved by the burnettizing method, namely, the injection of chloride of zinc only, with no other treatment to prevent the leaching out thereof.* The strength of the solution of chloride formerly used was 2½° of the Beaume scale, corresponding to 1.7% of chloride; and from 0.70 to 0.75% by weight of the pure chloride was injected. As many ties shattered and split under traffic, it was concluded that the strength and quantity of the injection was too great, and this has been gradually reduced until the strength is now represented by 2⅓°, and the quantity is from 0.50 to 0.55%. In the author's opinion, this is probably a mistake, for of 92,206 ties removed from six districts during 28 months, 87% were rotten, and only 11% were removed because of shattering.

This trouble with shattering has been found elsewhere with different materials and with very much higher strengths and larger quantities of the chloride, without, however, developing into any very serious matter. The German practice at some works is to use a solution of 3° strong, and the specifications for treatment at the Ruetgers Works require, in case of green or close-grained wood, into which it is impossible to inject the required amount of solution of 3° strength, that this strength shall be increased even up to 4½°, so as to secure the presence of an equivalent amount of the zinc chloride in all ties. The Chicago Works use at times a 3.8° solution and now inject 1% of chloride; and yet, out of 4,000,000 ties treated, not one broken tie has been reported. The best German expert advice is to the effect that the change in strength from 2½ to 2⅓° is entirely too small to affect at all the strength of timber. If the shattering at any time exceeded or nearly approached the destruction by rot, it was more probably due to the use of excessive heat or impure chloride.

The results of burnettizing were so satisfactory on the Atlantic System that a portable plant was built in 1894 for the Pacific System of the Southern Pacific Co., and when a change in location is necessary, the plant forms a train which has successfully traversed 16° curves and 3% grades. It consists of two retorts, 6 ft. in diameter and 114 ft. long, and has a capacity of 2,500 to 3,000 ties in 24 hours.* This plant was built under patents owned by Messrs. Curtis and Isaacs, both of the Southern Pacific Ry. A similar plant is now under construction for Mr. O. Chanute, to treat ties for the Chicago & Eastern Illinois R. R.

The experience of American roads with treated ties may be concluded to be generally favorable. The Atchison, Topeka & Santa Fe Ry. officials, after 12 years' trial on a large scale, believe they are getting from 11 to 12 years' service from mountain pine, having a natural life of about 4 years; while from natural white oak they get but 6 years in heavy main line service; and from cedar 10 years under light service.

The Union Pacific Ry. reports about 9 years for mountain pine and spruce. The Chicago, Rock Island & Pacific Ry. report of the count of ties now in place, indicates a life of at least 8¾ years. The unimpeached counts of removals prior to 1894 show that in that year 84.7% of the ties laid 7 years previously were still in track. The record of the four sections just west of the Missouri River, as here figured, indicates a life of 11 years. The Pittsburg, Fort Wayne & Chicago Ry. has hemlock and tamarack ties, only 1% having been removed after 7 years. The Duluth & Iron Range Ry. has white and Norway pine and tamarack which, after 7½ years' service and after having been taken up and relaid once, were still in nearly perfect condition in 1898. This furnishes conclusive evidence that the treatment is efficacious, and presumptive evidence that a life of 11 or 12 years may be expected.

The Southern Pacific Ry., operating on the most perishable material, with a life of only 3 years at the best, had 93% of the ties treated and laid in 1889 still in the track after 8 years. The record for the ties treated during the 2 previous years was not as good, for known reasons; however, those laid during 1887 gave 10 years' service, and of those laid in 1888, 63% were still in use 9 years later.

The woods which have been treated and used for a considerable time in regular service are the mountain pines, firs and spruces, hemlock and the sapwood of the yellow pine. The woods used experimentally are the cottonwood, sweet gum, red and black oaks, beech, tamarack and Norway and white pine. It can be expected that beneficial results will be obtained from treating any wood which will take the treatment well; that is, into which the proper amount of chloride can be injected. This is determined by the physical characteristics of the timber, the size of the sap ducts, the thickness of their walls and the amount of gummy substance contained in the sap.

It does not follow, however, that equally good service will be secured from two materials, even if they take treatment equally well. In German practice, beech and pine are treated with the same quantity of chloride, but the pine has 3 years' longer life, if both are burnettized. When creosoted the beech is apparently the longer lived by 50%.

The German practice is to treat only thoroughly seasoned wood. This is generally considered to be desirable in America also, but seems to be unattainable. Mr. W. G. Curtis, however, in his paper describing the practice of the Southern Pacific Ry. (Pacific System), states that freshly cut ties take the treatment much more readily than those partly seasoned; so that if the ties are freshly cut, they can get six charges through two cylinders in 24 hours; while if partly seasoned, they get but five charges. While this is probably correct for the particular timber treated, it is entirely contrary to the practice at other places, both here and abroad. At the Houston works of the Southern Pacific Ry. it is stated that if green ties and ties which have been seasoned for 3 to 6 months were subjected to the same treatment, the percentage of absorption of the seasoned ties would be much greater than the absorption of the green ties.

The Chicago Tie Preserving Co. finds it impossible to get satisfactory work with freshly cut ties, whether of hemlock, beech or tamarack. During 1898 this company ceased operating entirely for nearly two months, and piled up 70,000 ties in the yard, at considerable expense for rehandling, to permit them to season sufficiently to take the preservative. These peculiarities of timber, however, are not necessarily dangerous. It is simply necessary to fit the treatment to the material; and emphasizes two things: That such a cost should be allowed for treatment as to permit of occasional exceptional expense without loss, and that persons entrusted with such work should be above sacrificing the quality of their work for a small immediate gain.

It is well recognized that natural woods are more lasting if cut when the sap is down. Summer cut hemlock ties tested by the Chicago Tie Preserving Co. absorbed only about half as much as winter-cut ties. It was also found that some gum and pine ties cut in Virginia, North Carolina and Georgia, in September, absorbed two to eight times as much as ties from the same woods cut in April.

After treatment all ties should be allowed to dry, as is always done in Europe. Several lots were treated twice in Chicago, having absorbed in the first treatment but about 14% of their weight. All of this gain they lost in 5 months of seasoning, and 12% more; and were then in a proper condition for a second treatment.

The operations of the Chicago company's works are, of course, controlled by an elaborate system of measurements and accounts, so that it is known accurately how much of the antiseptics are absorbed by each run of, say, 400 ties. But it is not known how much each individual tie has taken, save in special experiments. Changes are in contemplation to circumscribe this uncertainty, and in this, as well as in other details, we shall have to profit by the experience of the Europeans, who have been preserving ties for about 50 years, and have materially improved upon their original methods.

In examining the records of tie treatment it is necessary to recognize the fact that the life of the exceptional tie, whether long or short, is of no value, except as a curiosity, and as containing a possible lesson in detail. The valuable thing is the average durability; and by this only can any results of real value be obtained.

The author has been impressed, while reading the statements of 10 years ago, with the fact that the advocates of preservative methods claimed too much. The life of treated ties was unhesitatingly put at 15 years, a limit which the occasional tie has reached, and which indeed, under favorable circumstances, has been reached by a

(Continued on page 418.)

---

*Engineering News, April 26, 1894, and April 14, 1893.
*Engineering News, April 4, 1895.

ENGINEERING NEWS
AND
AMERICAN RAILWAY JOURNAL.

Entered at the New York Post-Office as Second-Class Matter.
Published every Thursday
at St. Paul Building, 220 Broadway, New York, by
THE ENGINEERING NEWS PUBLISHING COMPANY

GEO. H. FROST, - - - - - - - - - - PRESIDENT.
D. McN. STAUFFER, - - - - - - VICE-PRESIDENT.
CHARLES WHITING BAKER, SECRETARY AND MANAGING EDITOR.
F. P. BURT, - - - TREASURER AND BUSINESS MANAGER.

WM. KENT, E. E. R. TRATMAN, M. N. BAKER, CHAS. S. HILL, J. J. SWANN, } ASSOCIATE EDITORS.

A. B. GILBERT, - - - - - - - - ASSISTANT MANAGER.

CHAS. W. REINHARDT, - - - - - CHIEF DRAFTSMAN.

ALFRED E. KORNFELD, New York,
M. C. ROBBINS, Chicago,
S. B. READ, Boston,
C. F. WALKER, Cleveland,
} ADVERTISING REPRESENTATIVES.

PUBLICATION OFFICE, 220 BROADWAY, NEW YORK.
CHICAGO OFFICE, 1636 MONADNOCK BLOCK.
BOSTON OFFICE, 299 DEVONSHIRE ST.
CLEVELAND OFFICE, OSBORN BUILDING.
LONDON OFFICE, EFFINGHAM HOUSE, 1 ARUNDEL ST., STRAND.

SUBSCRIPTION RATES: United States, Canada and Mexico, One Year, $5.00; 6 *months,* $2.50; 2 *months,* $1.00. *To all other countries in the Postal Union: Regular Edition, One Year,* $7.60 (31 *shillings*)*; Thin Paper Edition, One Year,* $6.31 (26 *shillings*). *SINGLE COPIES of any number in current year,* 15 *cents.*

In ordering changes of mailing addresses, state BOTH old and new addresses; notice of change should reach us by Tuesday to be effective for the issue of the current week. The number on the address label of each paper indicates when subscription expires, the last figure indicating the year and the one or two preceding figures the week of that year; for instance, the number 329 *means that subscription is paid to the* 32*d week* (*that is the issue of Aug.* 10) *of the year* 1899; *the change of these figures is the only receipt sent, unless by special request.*

ADVERTISING RATES: 20 *cents per line. Want notices, special rates, see page XIX. Rates for standing advertisements sent on request. Changes in standing advertisements must be received by Monday morning; new advertisements, Tuesday morning; transient advertisements by Wednesday morning.*

The Institution of Civil Engineers held this month the second of its biennial conferences, at its headquarters in London, and the proceedings were briefly described by our London correspondent in our last week's issue. The papers presented at this conference make a rather formidable mass of literature; but they contain so much of value and interest that we have thought it worth while to give up a large amount of space to them in this week's issue, and in order to do so without too much encroaching upon the space usually devoted to other matter, we have added eight extra pages to the present number.

The Institution has adopted a rather unique plan for the papers before its biennial conferences. It meets for its technical work by sections, and in each section those in charge have endeavored to secure papers from well-known engineers which shall summarize recent progress and current problems in the most important department of the industry, and shall do it in the briefest possible manner. The result is a collection of short meaty papers for the most part on live subjects, and while some of the authors failed to say much worth saying, most of them found it possible to condense a large amount of valuable, up-to-date information in a small space.

To suit the needs of our readers we have continued the boiling-down process, and have cut-off very summarily some of the papers whose authors failed to do more than present familiar text-book data, while others, of greater importance and value, we have given nearly or quite in full. The discussions, which were quite fully reported in our English contemporary "Engineering," we have cut down to very small compass, as they were generally of much less value than the papers, owing, doubtless, to the brief time available for them.

◆

The dry weather in some parts of the country during the last two or three months is already indicating the weak points in some branches of municipal service, and may yet cause serious trouble, if not complete break-downs, in many cities. Where the streets are not kept well cleaned and liberally watered one of the first indications of dry weather is an increase in street dust. Most of our cities are notably weak in their street sprinkling and cleansing departments, and, consequently, dust is now the order of the day. This condition has more serious consequences than the mere discomfort or damage to clothing and furniture. The dust which flies up and down the streets and sifts into houses, may carry with it disease germs, and is sure to irritate eyes, nostrils, throat and lungs. Besides this, the accumulation of dust on macadamized streets and roads hastens their destruction, especially when rain does come, and turns the dust into mud. This class of roads is liable to another kind of damage due to dry weather, the disintegration of the surface, and after that, of some of the deeper layers, through a complete drying out of the binder. Judicious sprinkling will greatly reduce, if not stop, this disintegration, at the same time obviating all the troubles due to dust. But injudicious sprinkling may turn the dust into mud, and soften the road surface so that its wear is increased.

The most serious effect of a long continued drought is the possible exhaustion of public water supplies. How insufficient some of our supplies are is shown by the fact that already much apprehension has been caused in some quarters lest these comparatively few dry weeks should cause the water supply to give out. While it is true that the present season of dry weather began most inopportunely in April, usually a wet month, in which the water level of storage reservoirs is raised instead of lowered, still there should have been enough water in reserve to have postponed apprehension of water famine to a much later date. In most instances little or no anxiety is felt as yet, but here and there are cities with scant stores of water, which are watching with grave forebodings the prospects of continued dry weather. And yet it is generally true that, even in large cities, all danger of a shortage might be averted for months if all, or even half, the waste of water were stopped. Warnings to this effect have been given already in several cities, but they make little impression unless they come in some more peremptory form than a mere request to be careful.

It is one of the perplexing problems of the water-works superintendent whose fortune it is to distribute from a limited supply, that in times of long-continued drought, the consumption of water for street sprinkling, and for watering lawns and gardens, grows apace; and just when the value of water for these purposes is the greatest it becomes necessary to restrict the use of water for these purposes. It is a notable fact that often these restrictions are not new ones; but are merely the enforcement of standing regulations, whose infraction in ordinary times is winked at. It is also noteworthy that these restrictions are not usually applied to metered consumers, unless the shortage of the supply becomes very serious.

In conclusion, it may be said that the water absolutely wasted in most of our cities, without benefit to anyone, would often be more than sufficient to sprinkle all the streets and water all the lawns in a most effective manner; and that where fixture rates prevail many consumers often waste and use ten times the water they pay for, thus running up the total consumption to such enormous figures that when a dry spell comes the careful and honest water user, who has always been paying for what he gets, suffers the shortage even more than his wasteful neighbor, who will manage somehow to continue to waste water regardless of the gravity of the situation. If the use of meters would not prevent water famines in all cases, as doubtless it would not, it would lessen their frequency and duration and compel each consumer to pay for whatever water he uses and wastes.

◆

In connection with the above reflections on the use and waste of water, it is interesting to note the low figures, given elsewhere in this issue, for daily per capita water consumption in English cities, cited in the papers before the recent meeting of the British Association of Water-Works Engineers, and the Institution of Civil Engineers. In this country little comment is raised unless the consumption exceeds 100 U. S. gallons per capita, while in England there is much talk of curtailing waste where only half that figure, or even less, is being delivered. Of course, conditions differ in the two countries, but some of these differences make the American figures just so much worse. For instance, about half of the total consumption in some English cities appears to be due to water used for public sanitation, such as sewer flushing and street sprinkling. The amounts used for these purposes here are rarely more than a small percentage of the total consumption. On the other hand, it was common until quite recently for English cities to have only an intermittent supply of water, for a few hours a day, and in general there are fewer plumbing fixtures in English than American houses. This last fact has less effect than might be supposed, owing to the more rigid inspection of plumbing fixtures abroad than prevails here. In some English cities, we are informed, water will not be supplied except through fixtures tested and stamped by the water authorities.

We notice that while the author of one of the papers, which we abstract on another page, seems to defend high rates of water consumption, and expresses himself strongly against metering domestic supplies, he has no word to say in favor of waste, always assuming that this will be kept down to the lowest point. He may be satisfied that this is possible without the use of domestic meters, but evidently there are English as well as American engineers who differ with him.

The paper on dual or auxiliary water supplies gives some indication of the seriousness of the water problem in England, where, notwithstanding the low water consumption per capita, compared with American practice, it has been found necessary or advisable to supplement the potable supply with water from some nearer and less pure source for industrial and sanitary purposes. We have supplementary water supplies, to a limited extent, in this country, but they are used almost solely for fire protection in congested business districts, having tall buildings, and supplement the pumps and distributing mains of the regular works, rather than the source of supply. Before providing dual supplies, on account of shortage in total volume of water, most of our American cities will do well to cut down their waste. In far too many instances the present domestic supplies are so badly polluted that if a dual supply were to be adopted the obvious plan would be to use the present system for industrial and public purposes and provide a second purified supply, of small volume, for drinking, culinary and laundry use.

THE PARTIAL ABOLITION OF WATER RATES AT DETROIT.

A radical departure from established methods of water-works financiering will go into effect in Detroit, Mich., on July 1, 1900, provided the bill recently passed by the Legislature of Michigan is signed by Governor Pingree. The new law abolishes all rates for water used for domestic purposes, and for water closets and wash rooms in buildings not used for residences. To make up for this reduction in the total receipts for water the "board for fixing water rates" must on or before May 1 of each year send to the Common Council "an estimate of the amount of money they deem a just proportion of the total estimate for maintenance" on account of this exemption. The estimate is also to include a sum for water to be used for all public purposes and supplied free to charitable institutions. The sum so determined is to be raised in the general tax levy. The balance of the estimated operating expenses "shall be assessed as water rate to be paid by the owner or occupant of each house or other building having or using water and against any persons using water, except for domestic purposes, in the city of Detroit, upon such basis" as the "board for fixing rates" considers equitable. The board just named is to consist of the superintendent of the water department, the mayor, president of the board of public works, city comptroller and city treasurer. The rates so fixed are to be collected by the tax receiver.

The operating expenses, including all repairs, are to be provided for as above. Next let us see how new construction is to be paid for and interest and sinking fund requirements on bonded indebtedness is to be met. The cost of all water main extensions up to 6 ins. in size, and so much of the cost of larger mains as is equal to the cost of a 6-in. pipe, are to be assessed upon abutting property in proportion to frontage. All other expenses for construction must be raised in advance by general taxation, except that deficiencies may be met, so far as the money will go, by surplus revenues from the department of charities and correction. If these surplus revenues are not needed for this purpose they go to the sinking fund. The main provision for capital charges is a yearly assessment, in the general tax levy, of $75,000, to be used first for interest charges and next for sinking fund accumulations. Any deficiency in the sinking fund (and interest fund) is to be met first by the surplus revenues just named and second from the liquor license fund.

The water-works, after July 1, 1899, are to be transferred from the present water board to the board of public works.

Assuming for the present that it is a wise policy to furnish water for domestic purposes without direct charge to the consumer, the scheme is still open to criticism. The whole of the interest and sinking fund charges are made a public burden, instead of being divided proportionately between the general tax levy and the water consumers, other than domestic, as is the case with operating expenses. All expenses for construction, also, are placed in the general tax levy, except that where mains are laid for the first time the cost of a 6-in. main is to be assessed on the abutting property. If the principle of assessments for benefits is to be followed, why stop with the cost of a 6-in. main, which would be absolutely useless without larger mains, pumping engines and boilers? Or, on the other hand, if water for domestic purposes ought to be furnished without a yearly charge, why make householders pay for the lateral pipes necessary to bring free water to them? The scheme would be much more consistent if the yearly operating expenses, charges on old indebtedness and cost of new construction were each determined and the total sum divided into two parts; one to be raised by a uniform general property tax and the other to be raised in the form of yearly charges for water actually used.

Coming now to the expediency or the reverse of supplying water to domestic consumers without charge, while at the same time collecting rates for all other classes of service, the principal justification we can see for the practice would be based on sanitary and hygienic grounds. Will such a practice increase the legtimate use of water in ways that materially affect the healthfulness of a community? We doubt whether a large portion of the population of any city would legitimately use more water when furnished free then when supplied at a moderate rate such as that now in force in Detroit. With the same number of fixtures in a given house, the actual use of water in the two cases would generally differ but little. So-called free water would undoubtedly tend to increase the number of fixtures in some houses; but, waste aside, the number of fixtures has less effect upon the consumption than is popularly supposed. In most cases it is the first cost of house piping, water closets and bath tubs, rather than the yearly charge for water, that retards the introduction of such improvements, and in the cheaper class of small and crowded houses the absence of these conveniences is often due as much to lack of proper space for them as anything else. Moreover, if this free water scheme is based on sanitary grounds, through the removal of all checks on the introduction and use of water, ought it to be accompanied with a provision for assessing the cost of water main extensions on abutting property? Such a practice might retard the development of the water service far more than a moderate yearly charge for water. It may be urged that such assessments generally fall on real estate speculators, or owners, rather than householders, but that cannot always be the case. It may also be urged that it puts a check on laying water mains in the outskirts in advance of building operations, but it also tends to congestion of population, instead of that wholesome spread of it into the outlying districts which all students of city problems favor with so much force and reason. We do not mean to say that special assessments for water main extensions are a mistake, but that they seem to be inconsistent with some of the most important aims of the new Detroit scheme.

From the question of the increase in the legitimate household use of water through making the service free it is natural to pass to its effect upon waste. This, we believe, is one of the most serious defects of any scheme for making the water supply, or any part of it, a charge upon the rates, as an English city official or taxpayer would say. One of the most important lessons in municipal economics which the Americans have to learn is that waste, and not use, is responsible for the bulk of water consumption; and that it is against waste that restrictive measures are used, or urged, by our most intelligent and conscientious city officials; further, the limitations upon quantity and quality of public water supplies, and pressure upon the public purse to meet other modern demands on city administration, makes the curtailment of waste an imperative demand of the near future. One of the strongest of human characteristics is to be most prodigal and wasteful of that which costs the least, or to fit the present discussion, the cost of which is least felt. We admit that where water is sold at fixture rates there is little enough check on waste and that perhaps many consumers will waste no more with water free than when paying fixture rates. But water bills at stated intervals do tend to bring home to the head of the family a realizing sense of the fact that running water all through his house costs both him and the city something, and in well-managed cities he knows that extreme wastefulness may lead to the setting of a meter. In addition, in so far as free water increases the number of fixtures, it will increase the waste. The most effective and economical means of checking waste is to use meters. While these do not prevent waste directly, they do indirectly, since those who are guilty of waste are compelled to pay for the water which they permit to flow uselessly away. But with free water the meter system is of course out of the question.

There remains for consideration one of the most important phases of the whole question of so-called free water; its effect upon the efficiency of a water-works system and also upon the development and maintenance of other branches of the city service. We see no way of keeping down waste where the free water system prevails. One of the chief motives for its adoption is its popularity with the masses, and a rigid system of house-to-house inspection to prevent waste would tend to defeat this very end. The situation would be worse yet if the detection of excessive waste was followed by shutting off the water.

Most, if not all, water-works superintendents know to their sorrow how difficult it is to secure appropriations for water-works improvements under the present system of raising the greater part of the revenue from water rates. Imagine what the difficulties would be in many cities if, in place of the small sums now inserted in the tax levies, were added the proportionate operating expenses for domestic and public water service, all capital charges on the uncancelled water debt and nearly the whole cost of new construction; and with expenses mounting up rapidly year by year on account of uncontrollable water waste, demanding increased sums not only for maintenance, but for larger mains and additional pumps and boilers! If the water service of the city did not deteriorate for lack of funds then there would be danger that some other branch of the municipal service would suffer through curtailment, for it is a well-known fact that increases in tax rates meet with strong opposition. The very officials who flattered themselves over the popularity they were gaining by introducing so-called free water would be in danger of losing more of it than they gained through an increased tax rate, or deterioration in the water service.

One other phase of the question might be gone into at length: The effect of the new plan on manufacturing industry. Owners of manufacturing plants will find both their water charges and their taxes increased by this plan, we should suppose. Is this either fair or wise?

Ten years ago Detroit had the unenviable reputation of being one of the greatest water wasters of any city in the world. This she has largely, but not wholly, retrieved since, at the same time reducing her water rates by degrees to very low figures. Consequently, her experience under this new scheme will be watched with interest, but the results cannot be known for some time, as the plan does not go into effect until July 1, 1900.

LETTERS TO THE EDITOR.

Concerning Fuel Saving Devices in Steam Plants.

Sir: Allow me to add my commendation for your "nerve" in exposing "fakes" such as the "Kalor" seems to be. I think this can be classed with the other fuel savers, such as "smoke consumers," "vacuum systems," etc. I had the misfortune to operate a large steam plant in this city for several years, and during that time the city authorities had two or three spasms of abating the smoke nuisance. The number of devices, costing from $2 to $500, that bloomed like the flowers of spring, was something astonishing—all fortified by credentials and testimonials which were copper-bottomed, if they had been made by anyone who really knew whether they saved any fuel or not.

I satisfied myself that no device would save any fuel that would abate the smoke, nor would any of the companies in the business guarantee that theirs would save fuel under a scientific test, conducted by a competent person. I put on a device under a battery of two boilers, which stopped the smoke, and I could not see that the fuel bills were increased. Its total cost was $15. Anyone similarly afflicted can have the benefit of it by sending me a stamped envelope.

In the plant to which I refer, exhaust steam was used for heating. A vacuum system was placed in the building under a guarantee to save 20% in fuel by taking the back pressure off the engine, etc. The result was that the company which put it in, took it out again at their own expense, and paid the mechanical expert who tested it $100 to have it demonstrated to them that the saving was so small, if any, as to be of no practical moment, coming nowhere near the guaranty.

Nevertheless that company was doing business at last accounts with a mass of affidavits showing the colossal saving that would result by using their device.

Your remarks are decidedly timely—that before any of these things are entitled to any serious consideration, they should be thoroughly and scientifically tested by mechanical engineers who know how to test them and whose professional reputation is worth more to them than the fee for making the examination.

It is certainly safe to say that owing to the many elements entering into the operation of any steam plant, no owner can tell whether this or any device is really saving him any fuel or not. E. T. Abbott, C. E.

403 Kasota Block, Minneapolis, Minn., June 23, 1899.

◆

Random Notes Abroad.

Sir: This letter will be gossipy from start to finish, with just enough reference to engineering matters to bring it within the pale of a professional engineering publication. It may remind some of the readers of Engineering News of their own experiences over the same routes and it may be useful to others who are planning to visit the Paris Exposition next year.

The noticeable improvement in ship ventilation in recent years strongly impressed me, when I crossed last on the "Teutonic." The horrible "smells" of past experience have been lessening in ubiquitousness and intensity in the later steamship construction until in the "Teutonic" they seem to have been completely overcome.

To passengers who are poor sailors nothing could add more to the pleasure of the voyage than this improvement.

The old-time uncomfortable "tender" for conveyance of passengers between the landing place in Liverpool and incoming or outgoing steamers is now a thing of the past. The facilities offered at Southampton by the American Line forced the railway, steamship and city autnorities of Liverpool to do likewise. Passengers now walk direct from the steamship deck to the railway shed, and after their baggage is passed by the customs officials, take seats in the special "cannon" train of the London & North-Western Ry. awaiting them, and are en route for London within an hour of their arrival at the dock.

What stories have we not heard of inconvenience and sometimes of serious trouble (with an occasional outrage or murder thrown in) of the compartment system of construction of English and Continental railway coaches!

While the Englishman contended for the superior "privacy" of his inaccessible compartment, the irrepressible American loudly and persistently aired his opinion of the comparative merits of the English and American systems, and, of course, in favor of his own: by dint of constant iteration the American idea won the day: the "Pullman" was admitted to English rails; the "corridor" train of coaches is the latest compromise, and comfort and safety, as well as privacy are now fairly well assured on the leading railways of Great Britain and the Continent.

The next compromise with the American idea of travel was in the handling of baggage. The ocean traveler, by sending a postal card in New York to the office of the London & North-Western Ry. Co., in that city, can have his baggage called for, taken to the steamer, and put on board checked for delivery at his home or hotel in London. Or, after passing the customs in Liverpool, he can have, for a charge of 6d. apiece, his baggage "registered" for delivery at the station in London. And, in Great Britain or on the Continent, "registering" one's heavy baggage is now the regular thing. It is not as convenient as our own familiar baggage checking system, but it is a distinct and important concession to the American spirit of progress. It is quite possible now to leave your baggage with the railway company for a day or two without claiming it—you have a paper receipt in your pocket which ensures its safe keeping. Nevertheless, there is still room for a large measure of improvement in this department of European railway service.

One important result of the new system of checking baggage over English railways is the decrease in "tipping" railway servants, especially in London. Mr. Richard Bell, general secretary of the Amalgamated Society of Railway Servants, said recently:

> From all I hear, the system has sustained a serious shock by the almost universal adoption of luggage checking, or the registration of passengers' baggage in advance.

The tipping system on English railways is responsible for "fluffing" and "weazling," terms quite unknown in America. "Fluffing" is a system by which, say, a signalman, after finishing eight hours in his "box," or tower as we say, goes to work on the platform without wages for what tips he can get. "Weazling" is when a man who has been standing on the platform idle, endeavors to steal or intercept the tips belonging to his fellow fluffer, who has had all the trouble of handling a passenger's luggage. While his mate is struggling with the last trunk he comes up with a handbag, touches his hat expectantly with the remark, "I think that is all," and frequently walks off with the tip he has not earned. Among other tip-hunters are the guards (conductors), who have five or six hours at their disposal before taking out their trains. Mr. Edward Garrity, financial secretary of the Society above mentioned, says:

> A passenger who can run the gauntlet of the posse of guards on the Great Northern departure platform without paying toll should receive a medal.

Imagine an American railway conductor—passenger or freight—hanging about a railway station in search of tips for handling baggage! But then, some of the railway companies have so reduced the wages of porters that these useful servants are absolutely dependent for subsistence upon the extra revenue they derive from tips.

The London & North-Western Railway Co. on June 8 tested the latest addition to their compound locomotives by a run from Euston to Crewe. The train consisted of engine, tender, and 14 coaches, of a total length of 716 ft., and the total weight, with passengers, consisting of 120 civil engineers and railway managers, was 425 tons 5 cwt. The length of the journey was 159 miles, and the maximum speed was 71 miles an hour.

Travelers from London to Paris can save about $5 in the expense of the trip by taking the Newhaven and Dieppe route. Large new steamers have been put on the Channel service and in good weather make the trip in three hours or less, as against one hour and twenty minutes by the Dover-Calais route. During the frequent severe stormy weather of the past winter, the Dover-Calais and Folkestone-Boulougne services, however, were seriously delayed or entirely suspended, while the Newhaven-Dieppe service, being in the more open channel, experienced comparatively little difficulty in making its passages on time, and were never suspended.

First-class traveling in English railways is very comfortable indeed. But unless expense is of no account, it is not worth the difference in cost over third-class which costs usually 2 cts. per mile, and on all the principal lines is the class mostly used. It must be remembered that the great mass of travelers on English railways are well-to-do people with whom economy is a fixed habit; it is a rare occasion indeed where one meets with a thoroughly offensive and objectionable character in an English railway compartment of any class. Smoking is confined to compartments specially reserved and labelled as such. Toilet conveniences are now liberally provided on all trains.

The French government taxes railway companies one franc per coach sent out on their daily trains. One consequence of this is an uncomfortable crowding in the insufficient number of coaches dispatched. Another and serious drawback to comfort in Continental railway travel is the quantity of hand-baggage stowed in each compartment. The following experience in Paris in securing one's seat in a railway carriage will answer for nearly all of Europe outside of Great Britain: Our luggage consisted of one steamer trunk, a large leather valise, an American dress suit case, a ladies' leather bonnet box, two hand satchels, and a shawl strap bundle made up of steamer rug, lady's cloak and an extra overcoat brought along for use on the Channel steamer; the rug and other wraps are absolutely necessary in a railway compartment in the winter months. We took care to be at the railway station one full hour in advance of the starting time of the day express for Marseilles. The cabman, paid and discharged; one porter trucked off the steamer trunk and valise to be weighed and registered; another porter carried away the other belongings; while my wife trailed after the latter, I followed the heavy baggage which after a little delay was passed, so much per kilogramme, a calculation absolutely beyond the reckoning of the rather bewildered tourist on his first trip. The charges on the baggage paid, and the porter "tipped off" one franc, the other porter is hunted up and a struggle for a seat is commenced. Although so long before starting the compartments are apparently all occupied. The porter peers into one after another of the coaches. A large percentage of them are "fumoir"—smoking cars—and in the others, while there may be but one or two persons, the unoccupied seats are loaded up with hand-baggage, which conveys the impression that the intending occupants are simply strolling on the platforms, cigar in mouth, perhaps, or seeing friends, awaiting the time of departure. If one appropriates one of these seats this may prove the fact, and then a new search must begin, and no porter to carry the luggage. After we had been turned away from several doors with the word "Complet," we were in despair of getting seats, when a cheery, stalwart Scotch woman from a compartment apparently already well filled, hailed us with the news that there was two vacant seats beneath the piles of hand-luggage. So we climbed in with many expressions of gratitude. The porter made room on the racks for some of our belongings; the others were left on the floor or the seats beside us; he was paid off and we settled down with a feeling of thankfulness that we had seats at all. For another half-hour later tourists came along the platform, their porters loaded with huge piles of boxes and bundles; the compartments were explored; "Complet" was hurled at them as they went back and forth. Near to starting time additional coaches were coupled on. Everybody got a seat—at least, we suppose so—and a few minutes after time the train pulled out on the 12 hours' journey to the Mediterranean shore.

London, June 14, 1899. G. H. F.

◆

Notes and Queries.

Recent gifts to Washington University, St. Louis, were briefly mentioned in the Notes from Engineering Schools in our issue of June 1. Maj. J. L. Van Ornum, Assoc. M. Am. Soc. C. E., who has just been elected Professor of Civil Engineering in this institution, writes us that the University has received $250,000 for the building and equipment necessary for its courses in civil, mechanical, electrical engineering and architecture, and $150,000 in addition for expenses of administration of these departments for the next few years. Besides the above amounts which were given specifically for the engineering departments, $900,000 has been given this spring for the University in general, which allows the immediate prosecution of plans for improvement and new buildings on the new site —five miles to the west of the present location.

◆

THE PRESERVATION OF RAILWAY TIES BY ZINC CHLORIDE.

(Concluded from page 415.)

considerable number of ties, and to which, with future treatment, as the operators become more skillful in the selection of material and its application, perhaps the average life may approach. The record of commercial use in the United States has failed to reach any such period, and it is entirely unnecessary that it should, to make the treatment desirable and economical.

The author believes his investigation has demonstrated that the cheaper woods, hitherto unused, are made fully as durable or more durable than white and burr oak, by burnettizing; and this fact is sufficient to make the adoption of the treatment desirable for many roads, if indeed it may not be said for American roads generally.

One point this inquiry has not solved is the relative advantages of the zinc-tannin or Wellhouse process, and the old method of burnettizing, using nothing but zinc-chloride. This hinges upon two points: The solubility of the chloride when deposited in the wood, and the efficiency of the chemical action between the glue and the tannin, required to form the particles of leather which are supposed to plug up the ducts. As to the first, there is general evidence that part of the chloride can be washed out of the timber, although it is not easily done. Mr. J. D. Isaacs, of the Maintenance of Way Department of the Southern Pacific Company, states* that he thinks this objection is greatly exaggerated. That the chloride is gradually leached out of material treated by the zinc-tannin process is probably true. A number of analyses of timber after years of exposure show considerably smaller quantities of zinc than it is believed they originally contained.

If the claims for the formation of the artificial leather by the tannin treatment are correct, and it is understood that this is verified by microscopic examination, it is probable that the leaching is delayed. That the treatment does not prevent the passage of moisture into the wood is evidenced by the rapidity with which the treated timber seasons, as well as by the loss of the zinc shown by the analyses. The results in future on the Atchison, Topeka & Santa Fe Ry. may determine the relative advantages of these two systems, as there are large numbers of ties now in use there treated by each. To insure the greatest success by either, however, it is believed that the injection of large amounts of chloride must be practiced, and, generally, this can be done only by using timber at least partly seasoned; and the subsequent partial seasoning before being placed in track.

Granting that certain woods may take the antiseptic in sufficient quantities even if treated green, so that it may not be accurate to say that it is necessary to good work that at least partly seasoned wood should be treated, there are certain other conditions which can be said to be essential to good work. These are pure zinc, pure acid, the absence of any free acid in the chloride solution, the use of a heat not exceeding 250° in the retorts, and sound, live timber to operate on. To treat dead or dozy wood is to waste time and chemicals. Chloride of zinc apparently has no power to stop decay which has already begun, and it is doubtful if any treatment is better in that respect. To these may be added faithfulness and integrity of a high order on the part of those operating the works.

To make the later identification of the ties certain, so that the life realized can be determined, it is believed that nothing will prove as satisfactory as the use of nails with large heads in which is stamped the current year, and which are driven in the center of the top surface of the tie when laid. The cost of such nails is but small, and they are more accessible and certain than any substitute.

Foreign Practice.—In France and Great Britain, the creosote process is used almost exclusively. The burnettized timber was apparently not satisfactory. Creosote is comparatively cheap, and the increased life of ties so treated is considered as worth the additional cost over burnettizing. The railways in the German Railroad Union, however, use very generally, either zinc chloride or a combination of the chloride and creosote, as well as creosote alone. Impregnation with the chloride alone has decreased, while that with the mixture of chloride and creosote has largely increased. Beginning in 1895 all the pine ties used on the Prussian State Railways were treated by the zinc-creosote process. This consists of the injection of the same amount of zinc chloride, with which is mixed creosote, in the amount of 1¼ lbs. per cu. ft. of timber; the mixing being done by a peculiar process. It is claimed that the results of this treatment are much superior to those with zinc chloride alone.

In 1885, the Ruetgers Works furnished one road with 171,000 pine ties treated with zinc creosote, on a 9-year guarantee. In 1894, at the end of the 9 years, only 29 had become unfit for use and none of these were rotten. Mr. Chanute is about to go to Germany to investigate this process, and it is hoped that he may be able to contribute the necessary data to the discussion of this paper, so that the value of the treatment may be determined. The additional cost over the regular burnettizing process varies with the price of creosote, but is about 4 cents per tie. The zinc-tannin process has never been used outside of the United States.

The German report on railways above referred to gives certain tables from which Table No. 1 has been compiled:

TABLE No. 1.—Costs and Results of Wood Preserving for the Union of German Railways for 1896.

	Chloride of Zinc.		
Kind of tie	Oak.	Beech.	Pine.
Cost of crude tie	$1.49	$1.01	$0.84
Absorption, lbs	24.2	34	34
Cost of treatment	$0.13	$0.15	$0.16
Total cost	1.62	1.16	1.00
Average life, years	15	9	12
Cost per year	$0.108	$0.13	$0.083
	Creosote.		
Absorption, lbs	15.4 24.3	66 79.2	50.6 79.2
Cost of treatment	$0.21 29	$0.50 59	$0.43 57
Total cost	1.70 1.78	1.51 1.60	1.27 1.41
Average life, years	24 28	30 34	20 23
Cost per year	$0.071 .063	$0.05 .047	$0.063 .061

In 1896 about 60% of all the wood ties in the tracks was impregnated in some way; and all of the increase in number of ties in track over 1894 was in the treated ties. Unfortunately, it is impossible to determine the number treated by each process in use by these roads, and the figures are of value only as indicating the general use of treated timber in preference to the crude. As a matter of interest, it may be added that the amount of track laid with metal ties increased from 13,550 miles in 1894 to 14,700 miles in 1896.

Cost of Treatment.—The economy of, or the saving to be effected by the use of treated ties, will vary with almost every road, being governed by the cost of white oak ties, cost of the inferior tie to be treated, and location. It has been attempted to determine what can be expected from the treatment and with the cost thereof given below, it can readily be determined which is the cheaper—a white oak or a treated tie. In the author's judgment, that is what the question resolves itself into. Apparently the evidence is conclusive that a treated tie is superior to white oak; but, if only equal to it, on the basis of cost in most locations the treated tie will prove the more desirable.

---

*Engineering News, March 11, 1897.

The cost of burnettizing sawed pine ties, 6×8 ins., 8 ft. long, on the Southern Pacific Ry., in 1893, was about 10 cts. each; while in 1897 it was a little over 6 cts. This includes nothing for interest on the investment, or depreciation. However, it is for a very small tie, containing only 2⅜ cu. ft.; and for an amount of zinc chloride only about half that required by German practice. On the basis of the cost in 1897 (2¼ cts. per cu. ft.), the use of the standard German quantity to be injected and a hewn tie of 3½ cu. ft., this cost would be about 12 cts. per tie, or 4½ cts. per cu. ft., including nothing for interest or depreciation.

On the Atchison, Topeka & Santa Fe Ry., the cost of the zinc tannin treatment, when the works were first built, was about 15 cts.; in 1892 it was about 14 cts., and 13 cts. for burnettizing (zinc chloride only). In 1897 the cost (zinc-tannin) was reported as 11.6 cts.; no interest or depreciation being included. It is understood that the charge made by the Chicago Tie Preserving Co. is from 16 to 20 cts. for the zinc-tannin treatment, covering, of course, interest and depreciation as well as profit.

The contract prices in Germany for burnettizing are as follows: For pine and beech, 5 cts. per cu. ft., and for oak 4 cts.; for treating with zinc-creosote, 6 cts. for beech and pine, and 5 cts. for oak; for creosoting, 15 cts. for beech and pine, and 9 cts. for oak. In creosoting, the amount of creosote is 12 lbs. per cu. ft. for pine, 15 lbs. for beech, and 4½ lbs. for oak. It is understood that the oak referred to corresponds to American white oak and not to the American red and black oaks, which will absorb as much as either pine or beech.

LEGAL DECISIONS OF INTEREST TO ENGINEERS.

Liability of Cities in Ohio.

It is not necessary in order to recover for injuries received by reason of an unguarded excavation, to show that the city had knowledge that it was being allowed to remain in an unguarded and dangerous condition, as it was bound to see that it was properly guarded.—Gable v. Toledo (Ohio), 90 Dec., 73.

Liability of City for Injuries from Electric Wires.

A municipality in Pennsylvania is bound to exercise careful supervision of electric wires over its streets, and is liable for injuries resulting from neglect of such duties, notwithstanding, also, the liability of the owner of such wires.—Mooney v. Luzerne, 9 Kulp's Rep., 230.

When Franchise is Protected by Federal Constitution.

The grant of a right to supply gas or water to a municipality and its inhabitants through pipes and mains laid in the streets, upon condition of performance of the service by the grantee, is the grant of a franchise vested in the state, and after performance by the grantee, is a contract protected by the constitution of the United States against state legislation to impair it: and this is equally the case whether the franchise is given directly by the legislature, or by municipal authority, to whom the right has been delegated by charter, and the courts of the United States have jurisdiction of a suit to protect such contract rights from impairment by subsequent legislation by either the state or the municipality, as the case may be. —Walla Walla v. Walla Water Co. (Supreme Court of the United States), 19 Supreme Court Reporter, 77.

◆

A NEW AUTOMATIC GAS LIGHTING SYSTEM is about to be placed on the market in the United States by the American Matchless Gas Lighting Syndicate, of 40 Wall St., New York city. The principle of the device consists in the heating of a piece of platinum sponge by occlusion of the gas until it reaches a temperature sufficient for ignition. The device is already in extensive use abroad, and its introduction in this country is being backed by the United States Improvement Co., of Philadelphia.

ANNUAL CONVENTION OF THE BRITISH ASSOCIATION OF WATER-WORKS ENGINEERS.

The fourth annual meeting of the association was held at London, June 5-7, in the rooms of the Geological Society. A canvass of votes at the opening sessions showed that Mr. Wm. Watts, F. G. S., of Sheffield, had been elected President.

President's Address.

The inaugural address of the President opened with some reflections on the training and qualifications of engineers. He thought the future promises to be bright for English water-works engineers, owing to the increasing demand for good public water supplies. Water waste must be checked. Dual water supplies were suggested to reduce the demand for pure water from distant sources and for filtered water. He had for years advocated the storage of moorland water, excluding floods, and the improvement of the water by sedimentation, exposure and bleaching. With small drainage areas and limited storage, filtration may be necessary, but with storage to the amount of 60,000 cu. ft. per acre of drainage area (about 288,000,000 gallons per sq. mile) most moorland waters are satisfactory if passed through a screen having 900 meshes per sq. in. This, however, presupposes absence of sewage pollution.

Report of the Water Areas Committee.

This report consisted of resolutions, which were unanimously adopted, to the effect "that the water supply of the United Kingdom should be subject to the general control or supervision of some independent" body or department. Among the reasons presented in favor of this resolution were that the problems involved were too great for local authorities acting singly, while voluntary cooperation was not often attempted; also that the interests of all concerned, and especially of the smaller local authorities, demanded a systematic general supervision of the division of available water among the communities needing it.

The Saline Constituents of Chalk Waters.

By Dr. John C. Thresh, Medical Offcer of Health, Essex County Council.

The object of this paper was to call the attention of chemists, engineers and geologists to the desirability of keeping records of all the facts pertaining to underground sources of water supply, especially chemical analyses of water from the chalk. The chalk water in Essex Co. is extremely variable in character, and the author believes that as its level is lowered sea water is drawn in.

The Biology of Sand Filtration.

By Dr. Ad. Kemna, of the Water-Works of Antwerp, Belgium.

This was the most important paper presented. Although pretty long, we abstract quite fully as follows:

In that concise and valuable work by Allen Hazen, the American engineer, on sand filtration, the number of people in Europe supplied with sand-filtered water is estimated at over 20,000,000. For the general engineer, and still more so for this special audience, no proof is needed of the importance of the general filtration of a modern water supply. But to the layman, the magnitude of the above figure may indicate a good deal, and impress upon his mind that we are here confronted with one of the biggest problems accruing from those gregarious habits which man, as a zoological species, shares with bees, wasps and ants; and advantage should be taken of every opportunity to enquire into the why and wherefore of a process of water purification so intimately connected with our welfare.

It is generally stated that the first sand filter was erected in 1829 by Simpson, for the Chelsea Company. Before the Royal Commission of 1827-8, appointed to enquire into the state of the supply of water to the metropolis, and also before a select committee of the House of Commons in 1828, Simpson appeared as engineer to the Chelsea Company. He stated that he had paid special attention to the subject of filtering during the two previous years, as he was fully convinced that the water could not be made clear by subsidence in reservoirs. At the request of his directors, he had traveled 2,000 miles in Lancashire, Lincolnshire, and Scotland, and had seen many manufactories and some water-works supplied with sand filtered water, some of them for a period of 16 years. Being asked about the necessary installations, he replied: "I have no doubt I shall be able to filter the whole of the supply, and the company has more than four acres of land applicable to the purpose, which, in my opinion, will be sufficient for their present and future wants." The yield of an experimental filter was 86,000 U. S. gallons for 1,000 sq. ft. in 24 hours, which is a good deal more than the quantity now considered as normal.

In this first period the only standard of purity recognized was the physical aspect of the water and those properties which immediately affect the senses. Simpson aimed at a mere clarification of the water, and he found his plant answered the purpose. The way in which the filter worked—that is, the theory of the process—was obvious. It was simply straining. The suspended particles were arrested on the top of the sand, because they were larger than the interstices between the grains, or could not wind their course through the sinuous channels in the depth of the mass.

When an experimental filter is started with clean and sterilized sand, only the grossest suspended particles are arrested; there is neither chemical purification nor reduction in the number of microbes, so that the efficiency of the filter is restricted to its mechanical action of straining. After a couple of days a layer of dirt has accumulated on the top of the sand, and then we find the filter working both chemically and bacteriologically. Now, if we examine this surface layer we find it teeming with life; green and blue algæ have interwoven their filaments into one felted sheet; diatoms, with their siliceous frustules (shells—Ed.) and gelatinous envelopes, fill up the meshes; zooglæa stick on every particle, and innumerable bacteria dot the whole mass.

The first effect must be the blocking up of the interstices between the grains of sand, the sticky nature of the covering also increasing in a marked degree the mechanical action of the filter; next we have to consider that all that material is alive. Plants are known, from the researches of Priestley and Lavoisier, to purify the medium in which they thrive, and the biological nature of fermentation has been advocated by Cagniard de la Tour, and experimentally demonstrated by Schwann in the third decade of the present century. Vegetable and bacterial life must needs alter the chemical composition of the water, and more especially destroy the organic compounds, which we know the filter does; and so biological theory gives a good explanation of the chemical action of the filter.

The bacteriological reduction is a very marked feature with sand filtration, 96 to 98% being common figures. At Antwerp, with a raw material producing 10,000 to 100,000 and even more colonies per cu. cm., the water after filtration is constant for months at 20. The microbes are not generally killed; on the contrary, they multiply enormously in the surface layer, the only possible explanation being that they get caught in the slimy layer on the surface of each grain of sand, so that the filter acts towards them like a spider-web.

This comparison is perhaps more true than would appear at first sight. The theory of a spider-web has been explained by Prof. Vernon Boys, with the aid of his extremely thin quartz fibers. When one of these fibers is wetted with a minimum quantity of oil, the liquid does not form a continuous sheath, but is fragmented into beads alternately large and small. The intervals between the beads act on sunlight as a grating, and give an interferential spectrum. All this is found similarly with the circular threads of a spider-web, and this arrangement of beads, which has been considered as a most marvellous piece of work of animal instinct, is only the natural result of the laws of molecular equilibrium of liquids, as set forth by Plateau. Both the spider-web and the quartz fibers catch flies, and this property is a consequence of the same purely physical action—namely, surface tension of liquids—for it is not necessary for the substance to be sticky: provided it be spread in an exceedingly thin film, it can act as a microbe-trap.

There are, however, at work in a sand filter causes which tend to destroy the microbes; light has been shown, by direct experiment, to be a very active agent in this respect, so that open filters are better than covered ones, unless the low winter temperature requires a protection against prolonged frost. Plants are maintaining the normal composition of our river waters, and with the aid of microbes, dealing rapidly with sewage; and if the auto-purification of running water has been questioned in former years by so high an authority as Sir Edward Frankland, it is because his experiments were constructed solely from the point of view of the chemist, and intended to settle the question of direct oxygenation by air, while biological actions were left out of consideration. According to the recent work of Dr. O. Strohmeyer, in the laboratory of the Hamburg water-works, green algæ are extremely energetic against microbes, sometimes effecting complete sterilization in less than a day. Although the experiments appear to have been made carefully, the results are so startling that a confirmation might be a good thing; perhaps the oxygen evolved by the plant is in the nascent state, or in the form of ozone, which is practically the same thing; and ozone has recently been proposed to effect the complete sterilization of water.

Although the microbes taken in bulk increase in number, it is, however, very probable that some species may diminish or even totally disappear, there being a keen competition and struggle for life. This is especially important from a hygienic point of view, as most pathogenic bacteria adapted to parasitic life are not quite at home in ordinary water, and are easily overpowered by the more essentially aquatic forms thriving in the surface layer of the sand. Moreover, it has been shown by Miquel, the French bacteriologist, that a water which has passed through a stage of preliminary contamination—such as is the case with most waters which require sand filtration—is not even after purification so good a cultivating medium as a naturally pure water, the previous development of bacteria seeming to have innoculated the water to a certain degree and for a certain time. Something of that kind has been stated to happen with the water of the Ganges, as it proves uncongenial to the cholera bacillus; so that, given two supplies—one of natural spring water and the other of sand-filtered river water—contamination in the first case is likely to be the more dangerous.

Directly the fact is established that living organisms play a most important part in filtration, the very next question is about the nature of these beings; are they plants, animals, or microbes? Which are, in the upper slimy layer, the commonest species? Are they always the same, or do they vary with different waters in different seasons? It might at first sight seem strange that for more than ten years nothing has been done in that direction, but this neglect is readily accounted for if we remember that these questions are completely outside the field of the ordinary engineer and chemist, and that they can only be taken up by skilled botanists and zoologists. Neither of these have paid special attention to the particular flora and fauna of sand filters; they had their hands full in completing the catalogue of life, or with the study of organization and development. How fruitful their endeavors have been no cultured mind can ignore. The idea of evolution is the direct outcome of zoological speculation; it has so completely permeated our intellectual life that it is only with some effort that we can realize the state of mind of pre-Darwinian science; even the two strongholds of antiquated reasoning—the scholastic hair-splitting of the law and the quibble of transcendental philosophy—have been largely affected. And any morphological or embryological work, however modest, was a contribution towards that grand work, but no such results could be expected from the tiresome study of our subject.

That this work has been undertaken is one of the good results of the cholera of 1892. This epidemic at Hamburg, and some other towns, caused about 10,000 deaths, or, say, one-third of the result of a great battle. Under its influence more sanitation has been done in six weeks than in ordinary times would be done in six years. When science does not reign supreme, mankind has to be taught by the bitter lessons of experience, they playing the part of the physiological rabbit. The Hamburg laboratory for the scientific study of sand filtration is an excellent institution; it is only right to mention the very good work done at Lawrence for the Massachusetts State Board of Health, and at the fresh-water zoological stations, the first of which was erected by Zacharias in 1892 on the Plöner-See, in Holstein. Several institutions of the same kind have lately been established in the United States, one by Professor Birge on Lake Mendota, and another, under the direction of Whipple at Mount Prospect, by the department of water supply of Brooklyn, N. Y.

The preliminary work at Hamburg consisted in making a very complete list of plants growing in the filter basins for one year. Each time a filter had to be cleaned the surface pellicle was examined under the microscope, the algæ alone being taken into account, the higher plants being considered only in a very limited way, playing no part at all in the subject of general filtration.

Algæ in general may be considered as unicellular plants; the living substance is a small nucleated mass of protoplasm surrounded by an envelope of cellulose, the outer layers of which are often transformed in a thick gelatinous coating. In the protoplasm there are colored bodies, often of constant and singular shape, of either green, brown, or bluish color. The protoplasm so colored is a chemical apparatus in which the energy of solar radiation is utilized in decomposing carbonic acid, water and nitrogenous salts, and in building up again complicated organic compounds, such as starch, sugar, oils, fats, etc., while in the process of decomposition free oxygen is evolved.

Strictly speaking, only a small number of algæ are really unicellular; the majority of species are composed of more than one cell, sometimes of a very large number; but practically the term unicellular means that the organism is composed of cells all of one kind; there are no differentiated tissues, no cells being specially modified to perform special physiological functions. A number of completely similar cells are united end to end or side to side, so as to form long threads, or jointed into spheres or disks, or arranged so as to appear like a stem with whorls of branches or leaves.

The best classification for practical purposes can be based on the color. The blue algæ are undoubtedly on the lowest stage of organization, the presence of a distinct nuclear body in each cell being still an open question. The green algæ also start from very simple forms, but attain to a much higher organization. The brown algæ or diatoms, are a side branch characterized by a silicious envelope composed of two parts, one overlapping the other, exactly like a wooden box and its cover.

Besides the plants generally resting on the top of the sand, owing to their being heavier than water, we must take into consideration those which float. Their buoyancy is the result of their protoplasm being specked with oil globules or with small bubbles of gas. Most of the bottom dwellers rise occasionally to the surface, when the oxygen evolved from brisk nutrition accumulates in their entangled masses. This is very important in practical sand filtration, as the covering is taken away and water allowed to pass more freely through the patches where the sand is laid bare; and the number of microbes in the effluent is found to increase markedly under these conditions. The biologist must be constantly on the look out, and when he sees a filter with a great quantity of these ordinary bottom dwellers floating on the surface, the yield of the filter should be at once diminished—in fact, such a filter should be worked with the same precautions as a new one. This occasional flotation is a serious drawback to the bacteriological purity of the water, but it is difficult to persuade foremen of this, as they look upon it as beneficial, because it yields them more water and delays cleaning.

The normal floating species, now generally designated under the collective term "plankton," also get to the bottom when they die. They sometimes appear in enormous numbers, as thick clouds imparting a distinct color to the water; then comes a period of excitement, both for the biologist and the engineer, although their feelings are not of the same nature, for the biologist revels in the splendid opportunity offered him for study, while the engineer curses the stuff itself and the biologist also.

The fact is that very serious trouble may arise from this cause. First, the filters are blocked in a short time, which means extra cleaning and consequent expenditure, besides diminishing the available supply, generally at times when the maximum yield is wanted. Then, drawing the water through a layer of decaying material impairs its quality; and last, but not least, some of these plants give off offensive odors even in the fresh state, and quite apart from decomposition.

The question of odor has been carefully studied in America, and an excellent summary will be found in Whipple's recent book, "The Microscopy of Drinking Water." Several species have been found troublesome in this respect, and each species has its own particular smell, so that an expert could identify with the nose the dominant biological composition of the water. Amongst the blue algæ the most offensive is Anabæna, and by treating cultures of this with gasoline, Jackson and Ellms extracted an essential oil which oxidized readily to a resin; the odor is described as greasy and moldy, but it becomes most disagreeable when the plant is decaying. A floating diatom (Asterionella), composed of a few cells arranged in the form of a star, is very frequent in American supplies, which are generally unfiltered; its odor at first is aromatic, somewhat like geranium, and then becomes fishy. Two species of Flagellates—Uroglena and Synura—are equally notorious in this respect, the former having a fishy and oily taste, the latter giving to the water a distinct smell of ripe cucumber, even when containing only from 5 to 10 colonies per cu. cm.

Upon decaying, the coloring matter of blue algæ gets liberated and forms a scum on the surface of the water, sticking to everything like oil paint. The late summer of 1896 seems to have been a most favorable time for Anabæna, when some of the ditches around the fortifications at Antwerp got covered with this scum, and the soldiers in the barracks near by complained of the bad smell.

At Hamburg it has been shown that there is a certain regularity in the nature of the plants found constituting the filtering film. In winter the diatoms are, so to say, alone, the number of their species is largely diminished when compared with what can be found in summer, but a few species make up the deficiency by the enormous numbers of their individuals. Green algæ appear early in the spring, and develop to a large extent in summer. The blue algæ are numerous in the hottest months and keep on growing in autumn, but they disappear in winter. During all these periods diatoms are constantly present, and are, therefore, of great importance, as they may really be considered as the filtering agent.

I am able, on the whole, to confirm these results. At the Waelhem works of the Antwerp Water-Works Co. an examination is made of each filter cleaned, and a record kept of the dates when the filter was started and when shut off; of the character, thickness, color and stickiness of the deposit; of the dominant forms of plants in the film; of the accessory forms present in such number that they play a certain part in the process, although not dominant; of rare and interesting forms occasionally met with; and of all biological events which have occurred in that filter during its life. After due consideration, I have not gone in for real enumeration of forms in the manner systematically carried out by Hensen, of Kiel, in connection with his plankton studies of the ocean, and adopted by Zacharias and others, or as applied to water supplies by the Lawrence biologists and all the American workers. It seems to me that the problem to be solved is not altogether the same. They are dealing with floating forms, while with sand filtration we have to examine the accumulation of forms in a layer; the two sets of data would bear no relation to each other, and I doubt whether much could be learned from the actual data for a top film. In order to get an approximate idea of the relative frequency of various forms, I make the total dominant forms to equal ten, and each species or genus has assigned to it a proportionate amount of this total. For example:

Melosira varians	5 =	50%
Fragilaria capucina	4 =	40%
Spiregyra	1 =	10%
	10	100

(S. tenuissima, dominant.)

which means that nearly the whole of the pellicle is composed of only two diatoms, Melosira being slightly in excess over Fragilaria, and the green threads of Spirogyra, especially of S. tenuissima, making about 10% of the whole.

This is part of the regular work of the Waelhem laboratory; it is as much as possible controlled by myself from my laboratory at Antwerp, and in many cases also by my friend, Dr. H. Van Heurck, the celebrated diatomologist. I most heartily thank him for the trouble he takes, while suspecting his motives not to be quite disinterested, as I think he hopes to be rewarded from time to time by some rare finds. The agreement between three observers is generally pretty close, so that the method seems to answer all practical purposes.

All the filters started at the end of January, in February, and at the beginning of March were cleaned in the month of April, and showed the same composition: The diatoms Melosira and Fragilaria were by far the most dominant species; the only and somewhat noteworthy form of green algæ was Spirogyra; while as to blue algæ only a few Oscillaria were seen. It was to be expected that later on the green algæ would appear and become one of the dominant forms; on the contrary, they have grown scarcer and scarcer. At the same time, there has been a change in the species of diatoms; instead of Melosira and Fragilaria forming threads, I find isolated cells of the specie Synedra and the small discs of Cyclotellia. The physical aspect of the covering has changed; with thread-like forms, the layer is thick, and has a certain toughness; it can be peeled off in small patches, especially if green algæ are present in noteworthy quantity; the layer is like felt. With the true unicellular forms, the layer is extremely thin and without any consistence; it is impossible to scrape off with the knife some of the deposit to make a microscopical preparation without bringing at the same time a few grains of sand on the glass slide. The bacterial efficiency of the filters is about the same.

Great practical importance is attributed by Strohmeyer to a moderate evolution of gas, not sufficient to tear the plants from the bottom and make them float, but just enough to keep them in an upright position. The growth of algæ is generally so abundant that if flattened out on the surface of the sand, they would form an impervious layer, which would have the effect of blocking up the filter much sooner. As the water glides down past the stems a good deal of the fine silt sticks to the gelatinous coating, and saves the sand from too rapid clogging, so that there is in this way a preliminary straining before the water reaches the real filtering surface on the top of the sand. According to my experience, by far the most effective species in this respect is Hydrodictyon, a green algæ with the cells in pentagonal meshes, and I have sometimes had a layer 1 ft. (?—Ed.) thick covering the whole surface. The filters then run a good deal longer, and when cleaning the men roll the growth up like a carpet.

The floral changes which in turn bring into prominence the brown, green, or blue algæ are undoubtedly due to the regular change of seasons. I have often noticed at these periods that, without any apparent cause, the bacterial results of filtration are impaired in a manner which the floral change may perhaps account for. When climatic conditions become unfavorable to the existing flora, their growth is more or less arrested, their vital activity reduced, and the forms present die out, to be replaced by the species of the next following season; but if the development of the latter is not so rapid as the dying out of the former, there is intervened a blank space of diminished life. It is probable that this explanation is partly true, but another cause seems also active, and that is the seasonal change in character of the bacterial flora itself. The most frequent species in the filtered water are not the same in summer and winter, and while at the beginning of a season the special forms have a tendency to appear in large numbers, there follows a time when it seems as if the filters got innoculated against them.

The animal kingdom contributes its share of trouble to the water-works engineer. The fresh-water sponge, Spongilla, is of frequent occurrence in ponds and reservoirs, attaching itself to stones and wood; as these sponges thrive on suspended organic matter, they tend to clarify the water; but, on the other hand, when they decay, it gives off a most offensive smell. Great troubles have arisen in some American water supplies and been attributed to sponges, but it is more probable that the real cause was Synura. Another form of adhering animal life are the bryozoa or fresh-water polyps—the so-called "moss"; these have a special tendency to fix their horny-branched tubes upon iron, and I have had a 24-in. pipe coated inside all round with such a growth 4 ins. thick, of course considerably diminishing the delivery, and imparting a most awful taste to the water, owing to the organisms being squeezed by the pressure in the pipes. I got rid of it by steaming and flushing, and from 650 ft. length obtained two cartloads of the deposit. At Rotterdam, Prof. Hugo de Vries reports in enthusiastic terms upon the zoological aspect of all the underground channels and reservoirs, the whole fixed population depending for its food on the refuse of small crustacea, which, in their turn, lived upon the unprotected wood of the piles on which the whole building had to be erected. Besides which, a ferruginous algæ—Crenothrix—found access to the filtered supply through the underground water, and was able to multiply at the expense of the dissolved organic matter, the growth appearing in tufts of yellowish or brownish color, and blocking up whole lengths of mains. The same trouble occurred at Berlin in 1877, and caused considerable damage. In all these cases good filtration is the remedy, as it deprives the organisms of their necessary food.

Neither fixed plants nor fixed animals are likely to give great and regularly recurring trouble. Their extension is limited to one plane, and the sides and bottoms of reservoirs have generally comparatively little contaminating influence in proportion to the volume of the contained water; but the floating organisms have it in their power to make use also of the third dimension. All the odor-producing species mentioned are floating forms. In another much higher class of animal, the Crustacæa, the swimming fresh-water order of Cladocera is, unfortunately, a close acquaintance of mine.

The most common form is Daphnia, also known as the fresh-water lice, the body of which is enveloped in a dorsal fold of the skin forming two side flaps, and it swims by means of the enormously developed second pair of antennæ. There are several different genera, and I have a nearly complete collection, having more than doubled the number of species of the Belgian fauna.

Cladocera become numerous in spring, when only females are present. Each individual produces a certain number of eggs, which develop in a dorsal breeding pouch without preliminary fertilization, and is an interesting case of parthenogenesis. As this process goes on for successive generations, it is easy to understand how, at certain times, ponds get absolutely crowded with them. In 1896 they were in thick clouds in my reservoirs and filter-basins, their dead bodies accumulating in a thick layer on the top of the sand. I resorted to screening the water through wire gauze, and for several weeks six men were kept busy night and day working the screens, and the total quantity thus taken out was over ten tons.

As the season advances two changes occur; males appear in very small number, and the females, instead of producing numerous eggs, have only two of large dimension, which get enclosed in a sac secreted by the breeding pouch; these are the winter eggs, which must be fertilized, and will only develop in the next spring. The case has somewhat the form of a horse's saddle, and is called the ephippium. When the winter eggs are appearing I know that my troubles are nearing their end; the floating ephippia are blown by the wind into the corners of the filter, taken out, and carried away in wheelbarrows.

Two insects are to be mentioned as sometimes affecting sand filters. One is a kind of gnat, named Chironomus, having an aquatic larva of red color, whence the name of blood-worm has been given to it. These worms burrow in the sand, cementing the grains into the form of dwelling tubes, and may be so numerous as to give to the upper layer a corrugated instead of a smooth appearance. As long as the worm lives in his tube the filter works well, but when the larvæ are transformed into the winged insects they come to the surface, and the tubes remaining empty and open, the filtering surface is riddled with innumerable holes. The filter, after having worked for perhaps ten days or a fortnight as usual, suddenly passes much more water, and the number of microbes in the effluent is increased, while as a warning that the process of metamorphosis is going on you see the swallows congregating over the particular filter to catch the insects as they arise. The eggs of Chironomus are embedded in a gelatinous cord, of which one end is attached to some object, and sometimes the sides of a filter at the water-level are covered all round with these streamers.

The second form is the hemipterous Corixa, approaching in general the aspect of Notonecta, or the water boatman. The three pairs of legs of the species C. striata I have usually found are very different in shape. The first is a thick, stout pair of curved limbs; the second is thin, slender, and hanging down; while the third is again very stout, but straight, pointing backwards, and fringed on one side with stiff hairs. If you have three or four individuals in a large jar of water with some sediment at the bottom, as soon as the sun shines they set to work, diving to the bottom and propelling themselves with their third pair of legs; with their slender second pair they get hold of a small mass of the sediment of algæ and rise with their load. Then with the first pair of legs they search actively for any prey that may be in the mass, and arrived in mid-water let go their load. In a couple of hours the whole deposit has been stirred up, the supernatant water rendered quite turbid; they are extremely active, but not so numerous as to disturb the filtering surface to such an extent as to impair the quality of the effluent.

The great phylum of vertebrates is represented on the black-list of the water engineer also by two species of fishes—the eel and the stickleback.

On several occasions a customer has been startled at getting a living eel from his water-tap; some years ago the water-works eel was a notorious event with the London press. It seems that the presence in such a place of such an animal can be explained only by the direct introduction into the mains of raw river water without previous filtration, which would be something more than even gross negligence. That this is the conclusion which has been jumped at by part of the public is not to be wondered at. But eels have been recorded in works where a direct communication between the pump well and the intake reservoir was impossible, and where, moreover, all care was taken. Eels not unfrequently come out of their natural element, and are said to have been found in meadows. The Italian zoologist, Grassi, has shown, only some years ago, that the young eel is a marine deep-water fish of quite a peculiar structure, and that after a metamorphosis it ascends the rivers. They swim against the current and crawl on stones and walls, sometimes several feet above the water-level. Now, most filters have pipes bringing the air in direct communication with the channels under the gravel to allow the air escaping when a dry filter is refilled, or to show the water-level under the sand and the loss of head. Very often also there is a pipe from underneath the filter to the intake reservoir, so that the first filtered water may be run to waste. All these pipes open above the water, and generally in the latter case the levels would not allow raw material running in the clean water tank; but the eels can climb up along the outer side of these pipes, and so get under the filters. It is necessary to have the openings of all such pipes protected by wire gauze.

I have had lately a curious experience with sticklebacks. At the Waelham works the water is raised on the filters by spiral pumps, and the small delivery tank of each pump is fitted with a screen. On May 24 one of the pumps broke down, and was replaced by a centrifugal, but the screen in the tank had to be taken away. That day the filters Nos. 3, 7 and 8 gave respectively 14, 34 and 32 microbes per cu. cm.; the following day the numbers ran up to 258, 292 and 242; the third day the results were good again.

Filter No. 7 was cleaned on May 27. It was noticed that there were patches of sand with numerous perforations of the upper layer, each group of perforations regularly distributed round a central larger hole; there were about 20 of these clusters, of a total area of 130 sq. ft. The laboratory superintendent thought that the filters had been running too low; that air had been introduced in the sand, and on escaping had made these small blowholes, but the men protested against the charge of negligence.

On May 2 filter No. 8 was cleaned, and here the patches numbered 100. On careful investigation it was found that the central large hole of each cluster was covered up by threads of algæ, weighted with small pebbles, and that under this covering there was a mass of eggs of the ordinary stickleback (Gasterosteus aculeatus).

Filter No. 4, cleaned May 4, showed the same characters.

The removal of the screen allowed the sticklebacks to reach the filters; the spawning period of the species falls in the end of April and beginning of May. The male builds a nest and hatches the ova—with the lower animals it is the male who takes care of the young. When the male has selected a suitable spot, he digs out a hole of oval shape, 1.2 ins. in depth and from 4 to 6 ins. in length, which he lines with a felting of weeds. Probably in searching for building materials, he has made the numerous small holes surrounding the nest.

A large number of additional facts could be mentioned, for the biology of sand filtration is co-extensive with fresh-water zoology, botany and with a good deal of bacteriology; but I have confined myself to the most important and interesting points, once more drawing attention to their scientific character and practical importance.

The discussion of this paper indicated that while the participants appreciated the value of biological studies of water supplies, comparatively little work of that sort was systematically done in England, outside of London. Several gave instances of stopping troublesome growths by covering reservoirs so as to exclude light.

Supplementary Water Supplies.

By W. G. Peirce, Engineer Water-Works, Richmond (Surrey).

Under the title "Auxiliary Town Supplies," the author described four plants for supplementing the regular potable supply with water more closely at hand but of a quality unsuited for domestic uses. The first of these is at Bournemouth, where sea water is used for street sprinkling and sewer flushing. Two pumping engines lift sea water through two 6-in. force mains to two towers, from which it is distributed through about 20 miles of mains. This water is supplied to 45 automatic flush tanks, at the dead ends of sewers, discharging 720 U. S. gallons in 1¼ to 3 minutes. About 120 other sewer dead ends are connected with the salt water mains, connections being controlled by 3-in. sluice valves, discharging 240 to 360 U. S. gallons per min., when in use. The quantity of sea water supplied averages 26 gallons per capita per day, against 30 gallons from the domestic supply. Mr. F. W. Lacey is borough engineer of Bournemouth. (The population of this place is estimated at about 60,000—Ed.)

At Great Yarmouth about 120,000,000 U. S. gallons of salt water has been pumped each year for eight years, and a lesser quantity before that, to supply private baths and for street sprinkling, drain flushing and fire extinguishment. Before the supplementary plant was installed the town council paid the local water company 20 cts. per 1,000 U. S. gallons for water for the purposes just named. The same service, though with cheaper water and on a much larger scale, now costs about 2½ cts. per 1,000 gallons, including repayment of the cost of the plant in 30 years. The council has decided to spend about $14,600 for new pumps, driven by electricity, capable of supplying 30,000 U. S. gallons per hour, doubling the capacity of the plant and further reducing the cost of water by one-third. Mr. J. W. Cockrill, M. Inst. C. E., supplied the information regarding Great Yarmouth.

Calcutta, India, is a notable instance of a dual water supply. According to Mr. Arthur Pierce, Assoc. M. Inst. C. E., Assistant Engineer, the intake for the main or domestic supply is some 14 miles from the city, on the banks of the Hooghly, where there are settling basins and filter beds. In 1874, an auxiliary plant was put in operation, drawing brackish water from the Hooghly, at a point in the heart of the city, and supplying it, just as drawn, by direct pumping. The auxiliary works have been enlarged from time to time, and on Feb. 28, 1898 there was put in use the first one of four triple-expansion beam Worthington pumping engines, with a daily capacity of 10,800,000 U. S. gallons, lifted 140 ft. The complete plant will also include four Babcock & Wilcox boilers, working at a pressure of 120 lbs., fitted with mechanical stokers, steam superheaters and economizers. The pumps will deliver into a 30-in. force main. Large quantities of crude river water will be used for flushing sewers. The relative cost of the regular, filtered supply, and the crude water from the supplementary works, including capital charges in each case, is about as 11 to 1.

The fourth auxiliary supply described by Mr. Peirce was that for which he is engineer, at Richmond, Surrey. Here water was first used for street sprinkling and sewer flushing in 1883, when a deficiency in the domestic supply made it necessary to stop using it for the streets and sewers. As a merely temporary measure Mr. Peirce set up a small boiler and pump in the water-works boiler house, connected it with a disused private main leading from the Thames and supplied one fire hydrant for filling carts. Subsequently another shortage led to the extension of this system, the river water being used for sewer flushing as well as street sprinkling. Still later it was decided to extend the system throughout the borough and to supply water to private consumers, for industrial purposes, lawn sprinkling and other uses. A part of the territory, at least, was already supplied by a private corporation at 14 cts. per 1,000 U. S. gallons. The auxiliary serivice was given at 10 cts., and had double the pressure (80 to 120 lbs.) afforded by the old supply. Small lawns are supplied with water for sprinkling at from about $2 per annum for 200 to 300 sq. yds. to $3 for 400 to 500 sq. yds., larger lawns being charged at meter rates. The highway department pays to this water undertaking about $5,000 a year for water used in sprinkling 22 miles of roads, in flushing sewers and for other purposes. For sewer flushing two men are constantly engaged, flushing every main sewer and the dead ends of all laterals. The highway department has 63 road-watering and fire hydrants; 89 sewer flushing branches; 5 public conveniences; 23 garden hydrants and services; and 1 spray fountain; making 181 connections. Besides these public connections there are 154 private ones, making 335 in all. Of the private connections, 127 are to private houses, lawns, gardens and fountains; 18 to industrial establishments for general uses, and 9 are private fire mains. The total water consumption from the auxiliary supply for the year ending March 31, 1899, was 82,700,000 U. S. gallons, averaging 230,000 U. S. gallons a day. The maximum daily consumption was in July and August, 327,000, and the minimum in January and February, 176,000 U. S. gallons. For the same period the combined supply, domestic and auxiliary, averaged 838,000 U. S. gallons, nearly one-fourth of which was from the auxiliary works. The consumption from the latter is still increasing, services for garden watering being laid free to the private property line.

The auxiliary system now includes two compound Worthington pumps, delivering 720 U. S. gallons per min. against 120 lbs. per sq. in. "into a dead main, two weighted relief valves being fixed on the delivery pipes, and thus dispensing with a storage reservoir."

There are 15 miles of 6 to 2-in. pipe, of which 6,483 ft. are 6-in.; 41,823 ft., 4-in.; 22,902 ft., 3-in., and 8,091 ft. are 2-in. The total cost of the plant is estimated at about $37,000. The estimated cost per 1,000 U. S. gallons pumped in 1897-8 is about 6 cts., including capital charges, and 2.4 cts. without. The total income for the year was about $8,000, not including any allowance for some 12,000,000 U. S. gallons supplied the steam plant for the domestic supply.

In the course of the discussion on this paper, one of the members alluded to the possibility of the impure auxiliary supply being used for drinking purposes, by mistake. He thought it would be necessary to guard against this. The consensus of opinion seemed to be in favor of a dual system, where local conditions favored it.

The East London Water-Works Co.

By C. E. Jones, Assoc. M. Inst. C. E.

The company supplies the largest area of any of the London companies, including a population of some 1,330,000, and delivering an average of 54,000,000 U. S. gallons a day through 1,000 miles of mains. The company was established in 1807, but it bought out one company founded in 1669, and another which had been in existence since 1720. The supply is taken from the Lea, the Thames, chalk wells and springs. The works include a number of pumping plants, filter beds and storage reservoirs, and are now being enlarged. There is a 48-in. Venturi meter connected with the works, capable of registering automatically 72,000,000 U. S. gallons a day.

Some facts regarding the visit of the association to the works of this company, with two views of its reservoirs, were given in our correspondence columns last week. The same letter also gave a brief account of the meeting.

THE BIENNIAL CONFERENCE OF THE INSTITUTION OF CIVIL ENGINEERS.

We present herewith a report of the proceedings of the biennial conference of the Institution of Civil Engineers, which took place at London, June 7, 8 and 9. The conference was divided into seven sections, as explained in the letter of our London representative last week, and we have reprinted below, more or less condensed, such of the papers and discussions as are of most interest to our readers.

Address of the President, Sir William Henry Preece, K. C. B., F. R. S.

We have gathered together from all parts of the kingdom to hold our second Metropolitan Engineering Conference; and we welcome here many who, temporarily at home, pursue their ordinary work in distant parts of the Empire, or in foreign countries. We represent every department of engineering practice, and we are here assembled to discuss questions of great pith and moment affecting the applications of the fundamental principle of energy to further the interests and promote the comfort, health and happiness of mankind.

This conference is not international, in the sense of that held in Chicago in 1893, or of that which I understand is contemplated in the year 1901 in Glasgow, in connection with the exhibition to be held there, but it may well be imperial. In whatever quarter of the globe we find ourselves, membership of this Institution has become a password.

The discussions set in operation in these conferences are based on short papers prepared for the purpose by those who have been selected as masters of their particular subjects, and invited by the council to lay the foundation of our talks.

The growth of engineering is illustrated not alone by the increasing number of affiliated institutions, societies, and members, but by the new fields of application which the advancement of knowledge and the progress of civilization are opening up. At the present moment, in ten distinct associations more or less intimately associated with our parent institution, there are some 22,700 paying members. Science, a much-abused term, is the systematized collection of the facts and laws of nature, and engineering is their practical application to the use and convenience of man. There is a great tendency to put the cart before the horse. Science has followed, it has not led engineering. It is their intimate association which is the foundation of all industrial progress. The war of the microbes, the latest development of biology, is a consequence of sanitary requirements. Our knowledge of the diffusion of molecules and the solution of solids have sprung from the investigation into the mechanical properties and constitution of iron and its alloys, and the disturbances of the æther are becoming familiar through the practice of the so-called wireless telegraphy. Facts are derived from accident, observation, or practice; laws are the result of research. Engineers have always appreciated science up to the hilt, but they wish that its special votaries were less dogmatic and more modest.

The Lord Chief Justice's Bill for the suppression of illicit commissions is one welcomed by every member of this institution, and it is most gratifying to find that no suspicion of improper practice has been adduced against our profession. We do, however, hear at times of a dangerous border-ground between consultation work and contracting, which is a pitfall to be avoided and to be surrounded by danger-signals. Again, occasionally, and fortunately rarely, we find the diploma of the institution converted into an advertisement; this the council strenuously protests against in the best interests of the entire body.

The examination system introduced just at the epoch of our first conference, has proved a most unqualified success, and it has been welcomed by none more than by those who are subjected to its troubles. During the last session, 107 candidates passed the associate membership examination, in addition to 31 who qualified by passing exempting examinations elsewhere, and 65 who satisfied the conditions of election by theses. Further 53 passed the institution examination for studentship, while 167 qualified in that respect by passing various recognized examinations. Thus we added 423 new names to our roll—all of whom satisfied the examination standards. The council feels that the system of examination has enhanced the intrinsic value of the diploma of the institution, and that it has added materially to the dignity and responsibility of the profession. This diploma has become so valuable and so necessary to the practicing engineer, that occasionally would-be practitioners improperly assume the title of members or associate. Fortunately criticism is too wideawake, and the public interest too well served by all who are jealous for the prestige of their profession, to permit deceptions of this kind to escape speedy detection.

The position of engineering has rendered it necessary for all new universities—and especially for the Imperial University of London—to form a faculty of engineering, but the council of this institution has deprecated the idea of conferring degrees in engineering. Every engineer must acquire a knowledge of the scientific principles and the mental tools that form the bases and aid the operations of his profession, but he can be an engineer only by becoming an expert in its practice. Examination can test the former qualification alone, and this is what we have introduced. Practical training is not a matter amenable to examination. Hence we consider that degrees in science are quite sufficient to signify the successful completion of a university career, which should be strictly scientific; and that the diploma of the institution should be the criterion of that professional qualification which is the result of practice alone.

Section I.—Railways.

WHAT IS A LIGHT RAILWAY, AND WHAT CIRCUMSTANCES SHOULD GOVERN THE GAGE.

By Arthur Cadlick Paine, M. Inst. C. E.

A light railway might be defined as a railway constructed to suit the class and volume or traffic likely to be conveyed thereon, the gage of which may be the 4 ft. 8½ ins., or standard gage of Great Britain, which is fast becoming the standard gage of the world, or one of the numerous lesser gages, such as 3 ft. 6 ins., the meter-gage of 3 ft. 3⅜ ins., or 3 ft., or 2 ft. 6 ins., or 1 ft. 11½ ins., or even 1 ft. 3 ins. As regards the last, this gage is believed to be only used in works, and is in no case authorized on lines for public traffic.

The advantages of a lesser gage than 4 ft. 8½ ins. may be taken for granted as a question of economy in first cost even in an easy country, much more so in a rough, hilly, or mountainous one; but it is not easy to see the advantages of so many variations.

Attention has been drawn again and again, but without much avail, to the desirability of standardizing these smaller gages, and making them, for the sake of argument, say 3 ft. and 2 ft. The standardizing of narrow gages to two types should lead to the development of a mileage of light railway lines greater than is at present thought to be possible.

"Time" is now becoming more and more the "essence of the contract," to use a specification phrase, and anything which will enable civil or military operations to be conducted with rapidity and certainty is of national importance. The fact of large orders for bridge-work, locomotives, carriages, etc., being recently sent to the United States was owing mainly to their ability to give prompt delivery if their own types were accepted, and points to the necessity for standardizing gage and stock in this country.

The discussion on this paper can be summed up by saying that the speakers almost without exception urged that all the so-called light railways should be made of the standard gage, and combated the idea that there was any important saving in first cost by adopting the narrower gages. With this conclusion, it is almost needless to say, American engineers will heartily agree. They will guarantee to build just as cheap railway lines to the standard gage as have been constructed of the narrow gages. The narrow gage fallacy cost railways in the United States many million dollars. The idea that the cost of building a railway line is in proportion to its gage is one which engineers should take every opportunity to uproot.

MOUNTAIN RAILWAYS.

By Charles Assheton Whately Pownall, M. Inst. C. E.

A mountain Railway, in this discussion, will be considered as including only the more important lines, with train-loads of at least 50 tons and gradients not flatter than 1 in 40. These lines divide themselves naturally into two groups. The first includes the passage of a main line over a range of mountains, interposed between the starting and objective points; and the second the projection of a branch line into a mountain region, either for the conveyance uphill of tourists or for the bringing of ores and minerals downhill from the mountains.

Then follows a further subdivision as to the method of construction and of traction, that is, whether the line is originally laid out for working by ordinary locomotives, which use adhesion only, or whether special engines, equipped with the rack and pinion, either on the Riggenbach or the Abt system, are employed, thus shortening the route by sharpening the gradient; or finally, in extreme cases, doing the same thing by breaking up the train into sections, each of which is sent separately up an inclined plane by rope haulage, as on the Sao Paulo Railway in Brazil.

Such departure from ordinary adhesion working is often justifiable on the score of expense when dealing with branch lines; it can hardly ever be so when it involves crippling a chain of through traffic by the insertion of a link on a special system, for the weakness of that link in traffic capacity will surely affect the whole chain.

On the more recent lines it is usual to reduce the gradient when passing over curves, so that the curve resistance, together with that due to gravity, will not impose on the engine a heavier task than that of the ruling gradient on straight sections. For rack lines with heavy loads this should not be steeper than 1 in 20, nor on adhesion lines should in be much, if at all, more than 1 in 40. To keep the gradient down to these figures, it often becomes necessary to increase the length of the ascent by development curves, of which, perhaps, the finest examples are to be found at the St. Gothard.

One of the most interesting questions for the engineer is the extent to which he is justified in increasing capital expenditure by thus adding to the length of the line, in order that his reduced gradient may enable larger and more profitable loads to be taken over it. The increased interest to be paid on a larger capital has to be weighed against the probable gain in revenue from heavier trains.

In the estimation of traffic it is necessary to consider not only the weight which can be hauled, but the speed at which it moves, for this directly affects the number of trains which can be run, especially on single lines, where the up and downhill trains have to pass alternately over the same track.

Where there is a choice of gage the larger it is the better, for this enables engines with wider fire-boxes and more heating surface to be used, and where large power is required, the locomotive builder is often cramped in his design by being tied to a too narrow gage.

In discussing this paper Mr. Aitchison emphasized the value of wide gages where rack-rail locomotives were to be used. These have more parts than any ordinary locomotive, and it is difficult to get them into the space available in narrow-gage engines. Colonel Holme, the contractor for the Snowdon Mountain Railway, said that with the 80 cm. gage line the trains had to be stopped during high winds, as they were in danger of overturning. Easy vertical curves should be used at all changes of grade, and electricity was much to be preferred to steam as a motive power.

THE ADVANTAGES, OR DISADVANTAGES, OF UNITING THE LOCK AND BLOCK SIGNALING APPLIANCES OF RAILWAYS.

By Alexander Ross, M. Inst. C. E.

A railway is naturally divided into sections by the stations provided to accommodate the traffic at various places along the route through which it passes, and these form, with some supplementary places where the distances between stations are too long, convenient divisions of the line for controlling and working the traffic.

A signal-box is placed at the end of each section, and in it is fixed the "locking frame" containing the levers for working the points and outdoor signals.

Each division of the line becomes a block section, and, by means of these, the line is worked on what is known as the absolute block system, which may be said, in short, to be a system by which a definite interval of space is maintained between all moving trains, instead of an interval of time, as in the early days of railways.

There are, however, two modifications of the above rigid rule, permissible under certain circumstances, namely, one known as the permissive block system, by which, under strict caution arrangements, more than one train is admitted into a section, and which is chiefly applicable to the running of goods trains; and the other, known as section clear but station or junction blocked, by which a succeeding train, moving towards a junction at which it will diverge on to a different line from that on which the train preceding it is traveling, is allowed to proceed slowly to the home signal of the box in advance, but, before entering on the section, it is a condition that the signalman at the rear box must bring the train to a stand and inform the engine-driver verbally of the state of the line ahead.

Every station is provided with the usual outdoor semaphore signals, generally for each line, a distant, a home, and a starting signal, and, where shunting takes place beyond the latter, an advance starting signal, with the usual complement of subsidiary signals, depending upon the number and nature of the sidings having connections with the main line.

The points and outdoor signals are worked by the levers inside the signal-box, and the movements of these are controlled by the locking in the frame, and are guided so as to lock and interlock in such a way as to produce a definite sequence of events, and to ensure that the positions of the points must be in harmony with that of the outdoor signals, and that, on the line being made for a passing train, the points must be in their right positions before the corresponding signals can be lowered.

It may now be observed that the locking apparatus, with the levers working the points and outdoor signals, in themselves as perfect as human ingenuity and good workmanship can make them, are worked independently of the inside block telegraph signals, the only connecting link between the two being the signalman who works both; and there is no physical obstacle to prevent him, in a moment of forgetfulness, giving outdoor signals in conflict with his indoor block instrument; and the question raised for discussion is, whether it is desirable or not, to unite and combine the two systems, either mechanically or electrically, into one complete system in such a way as to ensure, not only unity of action at one signal-box, but also with the next box in the rear and in advance.

The conditions which should be fulfilled by an efficient "lock" and "block" arrangement may be stated as follows, viz.: The rear signalman should not be able to lower his outdoor signals, or allow a train to proceed into the section in advance of him, until the signalman in advance has given him the necessary permission by unlocking the starting signal. The rear signalman, having received permission from the advance signalman to allow a train to proceed into the section, and having lowered his signals, and the train having moved forward on its journey, should be compelled to put his starting signal to danger; and the lever working the same, on being put back to the normal position, should become locked in such a way that it cannot be used again without the permission of the signalman in advance. This operation should free the home signal of the rear section, so that a second train may be brought forward to his starting signal; and, for the protection of this train, the home signal should be placed at danger, and, in the back stroke, become locked before a second train can be offered to the rear signalman.

When the first train has arrived at the signal-box in advance, and has passed his home signal, and the signal "train entered section" has been received from the signal-box still further in advance, the signalman must put his own signal to danger before he can give "line clear" to the signal-box in the rear for a second train. This applies when the section is from starting signal to home signal, but if the section is from starting signal to starting signal, the condition will apply to the latter.

The arrangements should be such as to admit of shunting operations, placing a train in a refuge siding, turning a train back, or slipping a carriage, taking place at any of the stations without break of continuity. The methods employed should be as simple as possible, and such as can be applied to the existing locking frames and block telegraph instruments, and be operated from within the signal-boxes in the ordinary working and without additional electric wires. It should be possible to cancel a train by the ordinary operations of the levers, without having to resort to special keys or releasers.

While long-distance locking must be made by an electric current, the moment this is effected the lock should be secured by a mechanical movement, and the current cut off, and all succeeding movements should be mechanical. The use of treadles should be reduced to a minimum, by preference avoided altogether.

The arrangement should be applicable, not only to "absolute block working," but also to "permissive block working," and to the warning method known as "section clear, but station or junction blocked," and should be equally applicable to single lines as to double lines of railways. It should be possible to apply the system to parts of railways effectively, such as at junctions, or the outlets of loop-lines, without disturbing the ordinary working of the other parts. The arrangements should be such as to render unnecessary the stoppage of trains proceeding under the warning rule by providing visual signals.

The real question at issue thus becomes, The advantage or disadvantage, of uniting the lock and block signaling appliances of railways.

If the conditions enumerated above are secured, the advantages appear obvious, some of which may be stated to be as follows, namely:

1. The impossibility of the outdoor signals being at variance with the indoor block instruments.
2. The rear signalman being compelled to forward a train to the man in advance.
3. The advance signalman being unable to accept a second train before his first has cleared out of the section.
4. Absolute protection for a train while in section.
5. Impossibility of the signalman in the rear forwarding any train in error.
6. The co-operation of three men in signaling a train.
7. The possibility of passing trains more quickly out of the section by adopting visual signals under the warning rule, instead of stopping the trains and communicating verbally with the drivers.

As to the disadvantages, they are somewhat difficult to enumerate. It is alleged that, with a long section, extending from starting signal to starting signal, delays may be caused when shunting operations are being carried on at a station, and unnecessary complications.

Discussion.—Mr. W. Loudon, of the Midland Ry., stated that all the principal railway companies had abandoned permissive signaling. Mr. W. H. Preece said that on the Metropolitan Ry. of London, the block sections were to be reduced in length by half in order to increase the traffic capacity of the line. Mr. Johnson thought it would be difficult to arrange a lock and block system at a busy station, to meet all the conditions which Mr. Ross had laid down. Mr. Lavey referred to the track circuit system as used in the United States, and said that it is now being tried on the Great Northern Ry. in a short tunnel.

THE VARIOUS SYSTEMS OF RAILWAY FOG-SIGNALING.

By Wilfrid Swanwick Boult, Assoc. M. Inst. C. E.

With the constant growth of railway traffic the question of fog-signaling becomes of more and more importance, and it is not surprising to find that for many years past a fountain of ideas—new and otherwise—for improving or superseding the established method has been steadily playing in the Patent Office. Thus for the sixteen years, 1877-92, the published specifications for "fog and audible signals" number 220. Of these, however, only a small proportion are worthy of consideration.

The following is a general classification of schemes of working:

A. Signals on the road:—(1) Men with detonators, lamps and flags. (2) Detonators placed by special lever in signal-box. (3) Detonators placed automatically by combined action of train and signal-wire. (4) Gongs, whistles, etc., controlled from the signal-box. (5) Gongs, whistles, etc., controlled by wheels of train. (6) Gongs, whistles, etc., worked by wheels of train. (7) Miscellaneous.

B. Signals on engine or train:—(1) Mechanical movement throughout. (2) Mechanical movement on engine worked by pull of road magnet. (3) Relay apparatus operated by mechanical contact with road apparatus. (4) Relay apparatus operated by road magnets. (5) Induced local currents. (6) Electrical contacts. (7) Miscellaneous.

Of these, the standard system A^1 at present holds the field; being, however, to a limited extent supplemented by A^2, A^3, A^4 and A^6. Other methods have as yet not been used as working signals, though a very considerable amount of experimental work with various systems has been carried out.

That the existing system, notwithstanding the good work it has accomplished, and the care and attention lavished on its development, is yet far from perfect will be generally conceded, and the point need not be elaborated. The question is, can it be improved upon? In the author's opinion it can.

Consider the object of the signal: it is to give information to the engine-driver. Surely, when visible road-side signals become invisible signals, it is better to do this by apparatus carried by the engine and capable of giving all the information wanted (danger and clear, distant and home, and which road made) than by trusting to a sudden explosion on the road to indicate "Signal on;" the absence of an explosion being taken to mean "line clear." If in clear weather a positive line-clear signal is required, much more is it required in fog, when the line ahead cannot be seen.

In the hope that this view may be generally taken, the author submits the following list of requirements as a basis for discussion:

1. Certain action.
2. Simple construction.
3. Slow deterioration.
4. Good protection from accidental damage.
5. Easy replacement of damaged or worn-out parts.
6. Minimum amount of cleaning and overhauling.
7. Moderate first cost.
8. Moderate maintenance and working expenses.
9. Signals must be given in the cab of the engine and in any vehicle fitted with receiving apparatus.
10. Action must be independent of speed or even movement of engine, and applicable as a starting signal.
11. Apparatus must work when engine is run either end first.
12. Two distinctive signals must be given—for danger and line clear respectively.
13. Distant and home signals must be clearly differentiated.
14. The signals must be capable of re-delivery at intervals as arranged.
15. Repeating in signal-box must be provided for.
16. A clearing signal should be given from the tail vehicle to the signal-box to show that the whole train has passed, and on which line, if more than one each way.
17. Commencing failure of action must be at once indicated while correct signals are still being given.
18. The failure of movable apparatus or electric currents on the road must result in the engine receiving the danger signal.
19. It must be impossible for the engine-driver by tardiness in stopping a bell or working a signal replacer, or otherwise, to prevent the receipt of a succeeding signal.
20. The whole apparatus must be unaffected by fog, frost, snow, rain, wind, or changes in temperature.
21. It must be posible for the apparatus to be made use of at a moment's notice whenever required.
22. It must be possible at junctions to indicate which road is made.
23. Each signalman should be able to veto "line clear" given by the signalman in advance, so that he may quickly stop a train on which he notices anything wrong as it passes.
24. The system must admit of lock-and-block and of automatic block working.

The above requirements are all successfully met by the author's system of magnetic signalling without contact, the working of which has been proved at top speed on a Great Northern express engine.

An important point to settle in the case of signals given on the engine is the form which these signals shall take. Suppose, for instance, that a miniature semaphore is used:

Is it to show for a few seconds only, and then automatically disappear?

Is it to be replaced out of sight by hand?

Is it always to stand as a record of the last signal received, and therefore of the conditions under which the engine is running?

Is a bell to be rung to call attention to the receipt of a signal?

If so, how is the bell to be stopped?

All things considered, the author believes the best arrangement is for the semaphore to always show the last signal taken, and for a bell to ring all the time the signal is on, unless stopped by hand in a way which cannot interfere with the semaphore at all or with the next ringing of the bell when a signal is taken.

Discussion.—The principal point brought out in the discussion was the difficulty experienced on any section of railway used by two or more companies in common, in the introduction of any complications in signalling devices. It was difficult to get the different companies to agree on the adoption of a new device.

CAUSES OF EARTH-SLIPS IN THE SLOPES OF CUTTINGS AND EMBANKMENTS OF RAILWAYS, AND HOW TO PREVENT OR REMEDY THEM.

By Elliott Cooper, M. Inst. C. E.

Slips in cuttings are occasioned by a greater diversity of causes than is the case with slips in embankments, one of the chief causes being that of water percolating from the surface through the more porous ground till a more or less impervious strata is reached, when it forces its way to the face of the cutting slope and thereby causes the mass above to slide forward.

The author finds a most effective way to prevent a slip of this kind is to put in a deep drain at the back of the slope and fill it in with dry stone. This drain should be connected with the side drains in the cutting by means of dry stone drains up the slope.

Another very common form of slip, in the coal fields, is that caused by the line being cut through strata with layers of rock lying at an angle steeper than 25°.

A cause of numerous slips, especially in deep cuttings, is the practice of driving a gullet right through, leaving the wings for months before being trimmed back. It is far better to excavate the cuttings in lifts and batter the slopes at once, so that the upper part gets firmly set before the bottom of the cutting is taken away. In all ordinary cases deep stone drains built up the slopes have a very good effect.

Slips in embankments are chiefly of two descriptions. First, where the material composing the embankment slips, and second, where the surface of the ground upon which the embankment rests slips away on the underlying strata.

The former is often caused by the material composing the embankment being of different descriptions, such as rock, clay, or shale. This form of slip can generally be stopped by building dry stone counterforts up the slopes and connecting these counterforts by dry stone pitching. In the case of high embankments, however, by far the best mode of forming them is by tipping in layers of from 15 ft. to 18 ft. high, taking care to keep the lower layers of full width so as to allow a cess when the next layer comes to be tipped. For appearance sake this cess can easily be trimmed off when the slopes are formed for soiling and sowing.

The second category of slips is much more serious and often entails great expense. Where the ground upon which the embankment will rest is of a wet and soft description, the most obvious and best preliminary steps to take are to intersect the whole site with wide dry stone drains, the depths varying according to the nature of the ground. If below this soft surface, at a depth of say 10 or 12 ft., or less, a hard strata is met with, great future trouble may be saved by cutting a deep trench along the site of the toe of the embankment and filling it with stone as large as can be conveniently obtained. This plan was adopted with very good results on one of the new lines constructed during the last few years in Derbyshire. The author adopted the plan of diagonal trenches, filled with stone on a long and high embankment (about 75 ft.) in Derbyshire with the best results, only three small and unimportant slips having occurred.

In another case piles were driven along the toe of the embankment with the idea of pinning the surface upon which the embankment rested to the hard strata below, but this was not successful, as the embankment forced its way under the soft material and lifted it and the piles about 10 ft. above its original level. Many expedients were tried to stop the slip, which was on side-lying ground, including wide and deep trenches, filled with stone up the slope, but eventually the embankment was completed by tipping many thousand yards of ashes into the embankment. This embankment would stand for months after being tipped to its full dimensions, and would then suddenly slip, and the slopes break away with a vertical drop of 8 or 10 ft. Since the ashes were used no further trouble has been experienced.

ECONOMY IN HANDLING AND TRANSPORT OF MINERALS.

By Charles de Neuville Forman, M. Inst. C. E.

The economical handling and transport of minerals is a subject which should command the best attention of the engineering profession. The magnitude of the work that has to be performed in this country every year in connection with this branch of trade almost surpasses comprehension. As far as can be ascertained, the total quantity of raw material, in the shape of mineral produce in the United Kingdom, which has to be handled and transported in some form or another, amounts to not less than 260,000,000 tons, so that every penny spent upon the handling and transport of a ton represents rather more than £1,000,000 sterling.

By far the most important product is, of course, coal, of which we raise upwards of 200,000,000 tons at an average cost of 5s. 5d. per ton. Iron ore ranks next, amounting to fully 16,000,000 tons, raised at a cost of 4s. 6d. per ton, and, in addition to the iron ore raised, we import fully 6,000,000 tons at a cost of 14s. 9d. per ton.

The most important means of transport are the railways. Fully three-fourths, or 153,000,000 tons, of the coal produced is transported by rail.

The standard clearing-house wagon freight-car used in this country tares about 6¼ tons for a 10-ton load, and, according to common practice, the wagons return empty. Thus, 12½ tons of dead weight have to be hauled for every 10 tons of paying load, so that more than 4½ millions are spent in handling dead weight. The tare of wagons used in the United States is about one-third of the load they are designed to carry. If the paying and the dead load were in the same proportion in this country, there apparently would be a saving of fully £2,000,000 in railway transport.

Proposals have been made recently to construct wagons of very much larger capacity than any at present in use in this country; but, looking to existing sidings, the load upon the axle, and the flexibility of the wheelbase, must now be most important factors in determining the economical design. In the author's opinion, four-wheeled bogie trucks, with an axle load of 8 tons to 9 tons, will be found in the end to answer best all the requirements of trade, and afford at the same time scope for economy in design. It is a subject to which attention may be advantageously directed; but the British system of following hard and fast rules, and giving no encouragement to the introduction of novelty in design, does not stimulate the inventor.

THE MOST EXPEDITIOUS METHOD OF RELAYING RAILWAY TRACK.

By Harry Footner, M. Inst. C. E.

All relaying of track requires: (1) A period of train "slackening" while preparing the old line for removal. (2) An interval of "absolute block" while throwing out the old line and laying down the new. (3) A further period of "slackening" while lifting, leveling, and straightening the new line until consolidated.

These periods will be in different proportions according to the method of relaying adopted, but the length of period (2), whatever it may be, must be so determined as never to stop an important train, and very seldom to stop any train whatever. In the interests of the traffic the engineer has to consider how he can reduce periods (1) and (3).

The methods of relaying may be classified as follows:

A. Gradual replacement of old with new material—such as turning the old rails out and the new rails into the old chairs—the latter with the old sleepers being withdrawn one by one and replaced with new chairs and sleepers.

B. Putting together all the new materials in one of the following ways before removing the old line: (1) Putting the new line together outside of and parallel to the old line; or, (2) Interlacing the new line with the old, the new rails being 9 ins. to 12 ins. from the old rails. Finally, the new permanent-way is slid into position as fast as the old can be removed.

C. Clearing away entirely the old line and preparing the sleeper-bed before putting the new materials together.

The author is of opinion that method A is more expensive in the long run than either of the others. Method B (2) may present the greatest advantages when the chairs have to be attached to the sleepers on the ground, and method B (1) is an expeditious way of executing the work during period No. 2, if the embankments and cuttings are wide enough and sufficiently free from obstruction to lay out the new material parallel to the old line; but he ventures to express the opinion that method C is best calculated to result in a good running road, and prefers it on that account for general adoption.

◆

Section II.—Harbors. Docks and Canals.

THE DISCHARGE AND RELOADING OF LARGE STEAMERS.

By William Henry Hunter, M. Inst. C. E.

Little more than 15 years ago a steamer of 5,000 tons dead weight capacity was regarded as a leviathan, to-day steamers of from 15,000 to 20,000 tons are in constant use, and the ordinary cargo steamer may be taken to be anything from 8,000 to 12,000 tons dead weight capacity. The development in the size of steamers has rendered necessary the provision of loading and discharging appliances, and of storage accommodation for their cargoes of an entirely new character. The necessity for these appliances, and for this accommodation, has become the more acute, as in many trades, such as that between the North American continent and this country, the cargoes are not only of huge weight and bulk, but are of an extraordinarily diversified kind, while the importance of despatch may be gaged by the fact that the expenses and charges of a steamer of a capital value of say £90,000 amount to at least £100 sterling per day.

Such a steamer trading between North America and Great Britain would make 12 round trips per annum, and would therefore be 24 times in dock in the course of the year, hence one day saved in the process of discharging and loading at the end of each voyage would mean a reduction in the steamer's expenses of £2,400 a year, or 2.66% upon her capital cost.

The case of a steamer of the class suggested engaged in the trade named will serve as an illustration of the requirements of present day traffic. Coming to this country she would carry on her upper deck some hundreds of live cattle. The regulations of the Board of Agriculture require that the cattle shall be inspected before any part of the steamer's cargo is broken up, and that they shall be slaughtered at the point of disembarkation. The rapid discharge of the steamer therefore involves, in the first place, that cattle lairages, with isolation zones, slaughter-houses and the multitude of intricate details required by present legislation should be provided. Next, it is necessary to provide for the steamer's general cargo. This will prove to be of the most heterogeneous sort, and will require not only to be turned out with great speed, and to be stored in sheds of absolutely weatherproof construction, but also to be sorted, trucked to marks and carefully arranged in those sheds for distribution. It is therefore clear that a great discharging area of floor space within reach of the ship is absolutely required.

At the same time, the timber, of which the steamer will have brought a large quantity, must be turned out; this involves the provision of storage grounds and a ready means of access thereto both by road and rail.

Probably the steamer will be fitted with cold-storage space in which a low temperature is maintained by artificial means for the conveyance of perishable commodities.

To deal with this class of trade, cold-storage warehouses, to which the perishable goods may be conveyed without delay, are required.

Thus we work down to the lower holds, upon the ceilings of which the steamer will have brought quantities of grain of very different sorts and qualities, requiring special appliances for its handling and special buildings for its storage.

It will be apparent that the problem of discharging say 10,000 tons of goods from a steamer of this character, and under the circumstances indicated, and of loading that steamer again, is not so simple as might at first sight appear, particularly when the fact is kept in remembrance that every unnecessary day spent in the operation means a loss of £100, and those who have been concerned in such matters know how quickly days slip away under these conditions.

Instead of attempting a general description of modern attempts to find a perfect solution of the problem, the author proposes to describe briefly the methods of working now in operation at the Manchester docks of the Manchester Ship Canal. It is not claimed that the methods in vogue are by any means perfect. During the short history of the canal traffic the pressure due to increasing trade has brought about a process of evolution, and the methods in vogue are the outcome of that process.

Beginning with the discharge of imported cargo and with the live stock. The cattle are landed at lairages which have been constructed in accordance with governmental regulations, are slaughtered, and the carcases, after being dressed and chilled, are forwarded by road and rail to all parts of the surrounding district.

For the discharge of the general cargo the vessel is berthed at the dock quays and the cargo is landed by hydraulic cranes (as many as seven or eight being employed for one steamer) and by the ship's own tackle. For the reception of the cargo, sheds of special type have been and are being constructed. The necessity for providing a great floor area so near to the vessel that the cranes may swing the packages, etc., out of the holds and on the floors at one operation has led to the addition of story upon story in the designs of these sheds until the recent sheds have been built with a ground floor and four upper stories. The strictest economy is practiced in construction, hence the design is of the simplest character, the cost of erection being reduced to a minimum.

In one case the cranes are placed upon the ground level, and are built with exceptionally long jibs, so as to permit of the landing of cargo on the upper stories. In the other case the face of the shed is brought within 9 ft. of the face of the quay, and the cranes are placed upon the fourth story.

Both arrangements have their advantages: (1) Placing the sheds at a distance of 36 ft. from the dock coping permits of a crane road and two lines of railway being laid upon the paved quay between the dock wall and the shed, and this again permits of the despatch by road or rail of any portion of the cargo for which orders have been received prior to the arrival of the steamer, as the goods may be deposited direct into railway trucks and lurries without being lodged in the shed at all.

(2) The placing of the sheds at the lesser distance of 9 ft. saves space and permits of the more ready discharge by hand into the various floors of the shed, of goods in casks and barrels which have been raised from the hold to the deck by the steamer's derricks.

To enable the discharge of this class of goods into sheds placed at the distance of 36 ft. from the coping, to be effected, as well as to assist in trucking other goods which have been lifted out of the holds by the ship's own tackle, a special type of movable gangways supported on telescopic piers has been designed and has proven to be effective.

The timber presents considerable difficulty, the space occupied by it in the process of discharging being so great. It is impracticable to move large vessels from berth to berth, while the necessity for speed also demands that the timber should be discharged concurrently with the general cargo, yet it is most undesirable to fill up the sheds and cumber the quays with timber. To meet this difficulty the author has constructed and is constructing timber-built pontoons, each pontoon being 150 ft. by 39 ft., and carrying 800 tons of timber or other bulky goods. These pontoons are berthed, end to end, on the off side of the steamer, and the timber is raised by the ship's derricks and turned out over the one side on to the pontoons, while the general cargo is being discharged by the hydraulic cranes over the other side. The pontoons when loaded are towed to the storage grounds, and so much of the timber as cannot be immediately consigned by road or rail is stored on these grounds.

The grain is usually discharged ex-ship by small portable elevators driven by steam power and loaded into barges holding 700 to 800 tons, and is by these barges conveyed to a large grain elevator of the American type, where it is stored and where whole cargoes of grain are dealt with direct.

One other point should be urged, i. e., that in the design of cargo sheds and appliances, a consideration of the greatest importance, and one which governs much of that design, is the provision of means for the ready distribution of goods from the shed, whether by road, by rail, or by inland canal, as under the most favorable circumstances loading out from the shed will require at least twice the time occupied in loading into that shed.

Discussion.—The chief point brought out in the discussion was that dock facilities should be suited to the traffic to be handled. Where cargoes are nearly all of one class of goods the problem of rapid and economical handling is much more easily solved. Railway tracks alongside of the quay wall were not approved, as it was deemed better to bring one or two lines of tracks down the center of the dock. It was also pointed out that the tendency was all the time toward a greater variety in the cargoes handled.

THE DIMENSIONS OF LOCKS, ENTRANCES AND GRAVING DOCKS, HAVING REGARD TO THE INCREASING SIZES AND CHANGING SHAPES OF VESSELS.

By Robert Cope Hardy Davison, M. Inst. C. E.

As docks are made for ships and not ships for docks, the present requirements of the merchant navy should first of all be glanced at. The cause of the growth and somewhat sudden increase in the average size of sea-going vessels was dealt with by Sir William White in this year's inaugural address to the Institution of Mechanical Engineers. The change from sail to steam; from iron to steel; the great extension of mechanical labor-saving appliances in the construction and working of ships; the vast improvement of marine steam engines and boilers; hydraulic, electric and pneumatic power, and refrigeration, were all shown to have had part in that tendency.

A few of the giants that now ply upon the different highways of the world are mentioned in the accompanying table:

Steamships.	Gross tonnage.	Length, ft.	Beam, ft.	Draft, ft.
North American Liners.				
"Kaiser Wilhelm der Grosse"	14,349	627.4	66.0	27.0
"Lucania"	12,952	601.0	65.2	....
"Kaiser Frederich"*	12,481	581.7	63.9	....
"Pretoria"	12,250	560.0	62.0	....
"St. Louis"	11,629	535.5	63.0	....
"St. Paul."	11,629	535.5	63.0	....
"Oceanic" (not finished)	17,000	704.0	68.0	28.5
"Deutschland" (not finished)	16,000	.....	....	....
The Cape Liners.				
"Briton"	10,248	530.0	60.3	....
"Carisbrook Castle"	7,626	485.0	56.0	....
East Indian & Australian liners.				
"India"	7,911	499.9	54.3	....
"Ophir"	6,910	465.0	53.4	....
"Polynesian"	6,506	482.3	49.2	....
South American Liners.				
"European"	8,194	475.9	55.0	....
"Orizaba"	6,298	460.0	49.3	....
"Danube"	5,943	420.0	52.0	....
General Cargo Vessels.				
"Algoa"	7,575	455.0	58.0	....
"Milwaukee."	7,317	470.0	56.1	26.0

*Recently dry-docked at Tilbury.

With regard to the North Atlantic liners, it would be rash to prophesy to what size they may attain. The depth at New York bar is now 30 ft., and 34 ft. is being aimed at, and Liverpool has 26 ft. at L.W.S.T. and is being improved every day. A new fleet for the Cape trade is spoken of with vessels 487 ft. long, 58 ft. beam, and a draft of 28 ft. loaded and 21 ft. light. The Suez Canal regulates the drafts of vessels trading to the East; it must not exceed 25 ft. 7 ins. at the present time. The South American trade is to some extent governed by the depth of the River Plate, being under 20 ft.

The large cargo ships are governed by all the foregoing facts, as well as by the shipbuilders and Lloyd's Committee. The author does not think the large cargo ship of the packing-case design can be said to be a success from the ship-owners' point of view, which is not always that of the shipbuilders. They are unwieldy and expensive to maintain, slow and difficult to steer when unloaded or with part cargo, and the premium asked for their insurance is believed to be higher. The author does not think they are a class of ship that has come to say, and looks to the vessel carrying 6,000 to 7,000 tons of cargo to come out triumphant in the end. A cargo vessel over 500 ft. long cannot be found.

Entrances to some of the chief ports: Liverpool, 100×600 ft. long; but vestibule basins to act as locks, 520×1,150 ft. with entrances 100 ft. wide and 32 ft. deep, are in contemplation. London—Royal Albert, 80×550 ft.; Tilbury, 80×700 ft.; Hull, 85×550 ft.; Newcastle, 100×320 ft.; Belfast, 100×80 ft.; Barrow, 80 and 100×700 ft.; Leith, 60×350 ft.; Manchester Ship Canal, 80×600 ft.; Plymouth, 80 ft.; Cardiff, 80×100 ft., large new dock in course of construction, with entrance-lock, 80 to 160×800 ft.; Newport, 72×503 ft.; Avonmouth, 70×454 ft.; Barry, 80 and 65×647 ft.; Swansea, 60×500 ft.; Antwerp, 81 ft.; Amsterdam Canal, old lock 60×394 ft., new lock 82×738 ft.; Kaiser Wilhelm Canal, 82×492 ft.; Bombay, 80 ft.; Calcutta, 80 ft.; Cape, 100 ft.

Graving Docks: London—Blackwall, 471×65×23 ft.; Tilbury, 846×70×35 ft., can be divided; Liverpool—New Canada Graving Dock, 925×94 ft., and 565×70×22.4 ft., and 768×60×22.10 ft.; Birkenhead, 750×85×26.7 ft.; Belfast, 800×80×25.8 ft.; Glasgow, 880×83×26.6 ft.; Southampton, 660×91×32.6 ft.; Plymouth, 464×80×22 ft.; Hull, 550×65×21.6 ft.; Leith, 410×70×21 ft.; Barrow, 500×60×22 ft.; Newcastle, 550×80×26.8 ft.; Cardiff, 618×62×27 ft.; Newport, 520×65×32 ft.; Barry, two docks, 747×60×28 ft. divided, and 610×65×29 ft. in construction; Antwerp, 459×81×23 ft.; Bordeaux, 540×72×27 ft.; Dunkirk, 622×68×26 ft.; Genoa, 622×68×26 ft.; Bremerhaven, 700×80×31 ft.; Brooklyn, 595×85×25 ft.; Sydney, 640×66×20 ft., and 608×84×32 ft.; Buenos Ayres, 587×65×26 ft.; Chili, 617×87×30 ft.

From all these facts—ships, entrances, locks and graving docks—the author thinks it may be assumed that, except in the Atlantic trade, there is not a commercial ship 530 ft. long, or 61 ft broad, or with 28 ft. draft.

The midship cross-section of cargo ships has altered completely and is now nearly rectangular, so that the curved invert of locks and entrances must soon be a thing of the past, and their shape become flat. This will necessitate thickening side walls. Where the docks themselves are too shallow, pumping in many cases is being resorted to, to keep the dock level at H.W.S.T.

It is not an advantage to have a lock of much greater width than the largest ship it has to accommodate, and many seem unnecessarily wide compared with their length. A wide dock-entrance with rounded corners is always convenient. It is economical to divide locks and graving docks so that one portion can accommodate a small vessel, while the whole length can be used for the largest vessel. Room and air-space is of advantage in graving docks—the system of having side bays, and propping vessels only on one side being the cheapest, and it is better to have a shallow dock for small vessels than to be constantly using a deep one for that class.

Working expenses are more worthy of consideration than original cost, and are too apt to be neglected in designing works. Quick dispatch necessitates no waiting for tides; if possible great depth of quay and shed space, so that each consignment may be at once dealt with; plenty of trucks, cranes and sidings; these must form part of the modern dock. The financial difficulty may lead to the transfer of most of our docks to railway companies—greatly to the benefit of the undertakings, as in the case of Southampton.

Discussion.—The author's proposition that a halt was being called in the increase of the size of cargo ships was vigorously combated by several speakers. The Suez Canal is to be deepened to 30 ft., and harbors in the East are to be increased in depth to correspond with this. In the Manchester Canal, Mr. Hunter stated, vessels drawing 25 ft. 6 ins. of water are passing without difficulty, and one vessel even passed with a draft of 25 ft. 11 ins., the depth of the canal being 26 ft.

SAND-PUMP DREDGERS.

By Anthony George Lyster, M. Inst. C. E.

The operations of the two big dredgers working on the Mersey Bar have been supplemented by an eroding apparatus attached to the tender from which the operations were superintended. The function of this apparatus was, by ejecting streams of water from a trailing pipe at high velocity on the ebb tide, to disturb and remove the lighter particles of overlying mud, which tended to interfere with the operations of the big dredgers. This eroding apparatus, after having been worked intermittently for some three years, has now been removed, as it was very doubtful whether the effect it produced was worth the expense of working it.

The following is the net result of the dredging operations from the point of view of navigation: Whereas at the commencement of work in 1890, the shallowest water across the bar was 11 ft. at low water of spring tides, there is now a channel of 1,500 ft. in width, having practically no less than 27 ft. of water in any part on the same condition of tide. The amount of sand which has had to be removed from the bar itself in order to effect this has been 22½ million tons, and from the bar and main channel 41¼ million tons, as stated above.

As a result of my experience in suction-dredging on the bar and elsewhere on the Mersey, I have been able to introduce an improved form of hopper, which obviates the loss of sand and mud which is washed over with the escaping water from the hoppers of the dredgers.

On an average it has been found that in the case of an ordinary hopper, about 30% of the sand and mud that is raised is lost through being carried overboard in this way. This material not only consists of light mud, but is also very largely composed of sand. Not only is this material uselessly raised at the cost of coal, wear and tear, etc., but as the operations are carried on in positions where the current, in one direction or another, is more or less constant, it is liable to be deposited and form shoals in the neighborhood of the dredging operations, or to overlay the sand with a fine deposit, which greatly interferes with the efficiency of the suction-dredgers. To overcome this difficulty, I have made the following arrangement:

The hopper of one of the smaller dredgers has been covered in with light iron plates, with the exception of a strip down the center of the hopper 4 ft. in width. Here a trunk 5 ft. in height and 4 ft. in width, by the full length of the hopper, is formed by vertical plates of iron, carried up above the covering of the hopper. The upper edges of this trunk are fitted with adjustable coamings, to ensure an even overflow from the hopper independently of the trim of the vessel.

At the same time, the discharge-pipes in the hopper are laid as close to its outer sides as possible, and the openings in them are so formed as to ensure the sand and water being delivered with a minimum of commotion. The effect of this arrangement is that all water passing from the hopper overboard has to traverse a considerable distance in passing from the discharge orifice in the pipe to the upper edge of the trunk over which it flows. The sectional area of the trunk is such that the rate of vertical motion through it is reduced to a minimum. The head of water which the trunk affords, and the fact that, in the course of its discharge, it has to rise vertically, has the effect of producing a steady and almost imperceptible flow of the water, which is thus unable to take with it any sand or silt.

The experiments with this apparatus at the landing-stage show that, as compared with the other dredger, which is not so fitted, the discharge water from the special hopper is clear in appearance, and gives practically hardly any percentage of silt, whilst the dredger is able, on an average, to load herself in 20% to 25% less time than the one that is not so fitted. This result is a most important one from the point of view of the output of the dredgers during the year, and the cost per ton of dredging, whilst it also permits this type of dredger to be used for lifting very fine sand and mud, for which it has not hitherto been capable of being used economically.

Discussion.—It was brought out that the depth of a dredged bottom in sand which would remain undisturbed except by the hardest storms, was from 20 ft. to 30 ft. It was thought that the suction dredge with suitable cutters could be depended upon to handle stiff clay and other hard materials, not including rock, of course. The difficulty of handling the silt which was deposited around docks was its light specific gravity, which made it flow off with the water instead of settling.

THE EFFECTS OF WAVES ON BREAKWATERS IN DIFFERENT DEPTHS OF WATER.

By William Shield, M. Inst. C. E. (Peterhead).

The circulation of the water particles in waves of oscillation appears to be nearly such as would be produced by rolling circles having their diameters equal to the height of the wave, trough to crest; and the form of the wave is therefore approximately cycloidal. As, however, waves pass into shoaling water they are affected by bottom friction, and their form is altered, the orbits in which the particles revolve becoming inclined and elliptical. At length the friction of the bottom is such as to cause the crest to overrun the face slope, and the wave breaks. The forward motion of the particles at this time is equal to the velocity of the wave, and the wave-stroke is delivered with its most destructive effect. Waves generally break on entering water the depth of which but little exceeds their height, trough to crest. It may therefore be assumed that the height of waves can never exceed the depth of the water over which they travel. Long ground-swell waves, although insignificant in height, are, however, often transformed into waves of a very dangerous character.

It will therefore be evident that in all depths of water in which it is possible to construct breakwaters, storm waves will, in a greater or less degree, be waves of translation, while smaller waves may for all practical purposes be considered oscillatory.

The velocity of storm waves which assail breakwaters, inasmuch as their length is always much greater than the depth of water in the immediate vicinity of a breakwater, is proportional (sensibly) to the square root of the depth; it is, in fact, the same as the velocity which a free body would acquire by falling from rest under the action of gravity, through a height equal to half the depth of the water.

Where V = velocity of wave in feet per second.
g = unit of force of gravity = 32.17 feet per second.
s = in this case, one-half depth of water in feet.

$$V = \sqrt{2 g S} = 8.02 \sqrt{S}.$$

The breakwater which is being constructed by the Admiralty at Peterhead is of the vertical type, and is composed of concrete blocks, weighing about 40 tons each, laind in regular horizontal courses, joggled and set in Portland cement mortar above low water. Waves up to say, 10 ft. or 12 ft. in height range up and down against its face without breaking or apparently exerting any force beyond the hydraulic pressure due to their height; larger waves, however, behave in a very different manner.

During the storms of December, 1896, and January, 1897, blocks weighing 40 tons each were displaced in courses bedded respectively at the levels of 17 ft. 1½ ins. and 23 ft. 7½ ins. below L. W. O. S. T. One of these blocks lodged on a concrete platform 30 ft. 7 ins. below L. W. O. S. T., and was washed away during the storm which occurred in the following March.

During the storm of October, 1898, which is said to have been as severe as any that has been witnessed in Peterhead Bay, the waves were upwards of 30 ft. in height. Blocks weighing upwards of 41 tons each were displaced at the level of 36 ft. 7½ ins. below L. W. O. S. T., and a section of breakwater, down as far as 10 ft. 7½ ins. below low water, and weighing 3,300 tons, was bodily slued to the extent of 2 ins. without the blockwork being dislocated. This enormous mass slid upon the surface of the blocks forming the course the top of which is at the level named; and they, strange to say, were not moved. The surface on which the waves operated measured 33 ft. × 34 ft. = 1,122 sq. ft., and the height to which the water was thrown was about 115 ft. to 120 ft.

In order to enable an idea to be formed of the force required to slue this mass, the author ascertained the coefficient of friction of blocks similar to those which form the breakwater, by causing them to slide upon a concrete floor. The floor was well wetted, and the average of several trials with blocks up to 68 tons weight gave a coefficient of 0.7. In moving this mass the waves must therefore have exerted a force of 2,310 tons, or slightly over 2 tons per square foot, over the whole area exposed to them. Although about one-third of the mass was below the level of low water, the troughs of the waves would be considerably below its lowest point, and taking all the circumstances of the case into consideration, it is thought that little, if any, allowance should be made for flotation. If, however, allowance be made for this it is probable that some deduction should be made from the area exposed to the wave-stroke, so that the force per square foot would not be much affected.

The depth of water where this happened was about 9 fathoms at L.W.O.S.T., deepening to 20 fathoms at a mile to seaward. The rise of a spring tide is 11 ft. The length of the waves was about 550 ft. to 600 ft., crest to crest, and the depth of water at mean tide 60 ft.

The comparatively high rubble foreshore of all such composite breakwaters as those at Alderney, Colombo and the Tyne, without doubt greatly increases the force of the waves against their superstructures. The downward action of waves operating against the face of a vertical breakwater often causes serious damage by undermining the foundation. The breakwaters at Alderney and the Tyne are prominent and lamentable examples of this. High parapets, such as both of these breakwaters possessed, greatly intensify this action, and are on this, as on other accounts, objectionable.

Mixed rubble, composed of stones weighing from say, 5 tons downwards to about ½ cwt., forming an apron on the seaward side of a vertical breakwater, appears to be but little disturbed at a depth of 36 ft. by waves 30 ft. high; but around the scar-end the scour is very severe, and, unless protection is afforded, the rubble at this point will be washed away, even at depths exceeding 40 ft.

In a composite breakwater with a vertical superstructure founded on a rubble mound, the height to which the mound is carried in relation to the levels of high and low water is of vital importance, and is therefore worthy of careful consideration. Holyhead breakwater is an example in which the mound was carried up to the level of H. W. O. S. T., and in which the artificial boulder beach thus formed effectually breaks up the waves before they reach the superstructure. The slopes which the mound has now assumed by the action of the waves are approximately 1 in 12 between high and low water; 1 in 5 from low water to 8 ft. below it, and thence to the bottom (about 50 ft.) 1 in 2.

Alderney breakwater is an example in which the mound was stopped below the level of low water, the rise of tide being 17 ft. The force of the waves assailing the superstructure was thus greatly increased, and the result was disastrous. The slopes assumed by the surface of this mound varied considerably; but at 1,000 ft. from shore, where the water was 45 ft. deep at L. W. O. S.T., they were as follows: 1 in 6½ from 3 ft. below low water (that being the highest point of the mound) to 17 ft below it, and thence to the bottom 1 in 2. In this breakwater the waves not only undermined the superstructure by withdrawing the rubble on which it was founded, but they formed breaches in the wall by their direct impact, while the water falling upon the roadway excavated holes in it, until, meeting those on the sea face, the work was bleached completely through. Strange to say, the parapet, in at least one case, spanned the breach and survived the storm. A very similar action took place at Wick and at the Tyne.

In the above class of breakwaters, when the mound is not carried up to the level of high water, the addition of a wave-breaker of heavy concrete blocks is often useful, inasmuch as it relieves the face of the superstructure from the force of the wave-stroke, and the waves being in a great measure broken up do not exert so great an excavating action on the rubble as they would do in the absence of such protection. When the Yminden breakwaters (Holland) were being constructed, before the blocks forming the wave-breakers were deposited, the rubble which forms the aprons of these piers was frequently ploughed out at a depth of upwards of 20 ft. below low water. The wave-breakers were, however, effectual in checking this action, and after they were added little inconvenience from this cause was experienced.

Many of the 20-ton blocks in the wave-breakers were disturbed by the waves, one being lifted a height of 12 ft. vertically up the face of the pier and landed on the top of it. 7-ton blocks built into the work were started forward out of their places by the impact of the waves on open joints compressing the air behind them, which, on the withdrawal of the wave, expanded and pushed the blocks out. On more than one occasion considerable lengths of courses, the full width of the pier, composed of blocks weighing 5 tons, 7 tons, and 9 tons, all of which were set in Portland cement mortar and tied together by strong wrought-iron cramps, were displaced and washed over into the harbor. The depth of the water was 23 ft. the rise of spring tides about 5½ ft., and the height of the pier 4 ft., 10 ins. above high water.

Other points which suggest themselves for discussion, especially in connection with the effect of waves on breakwaters during construction, are (1) sloping versus horizontal bond for blockwork on a yielding foundation, with which, in view of the liability of horizontal courses to slide one on the other, might be associated a consideration of bond between the courses, and also the most effectual method of dealing with settlement in horizontal coursed work; (2) the best method of checking the travel of rubble in breakwater mounds subjected to oblique wave action; and, lastly, (3) the best means of avoiding or reducing the destructive effect of wave-stroke on exposed open joints, especially under water, inasmuch as this action is operative at much greater depths below the surface than is generally suspected.

Discussion.—Instances were mentioned where blocks of masonry of great size had been displaced by the waves at 20 ft. to 40 ft. below the water surface. Present practice recognized this danger by placing the foundations of several important breakwaters now under construction well below the possibility of wave action. The foundations of the breakwater at Peterhead were 43 ft. below low water, at Tyne they were 44 ft. below, at Colombo they were 31 ft.

THE DESIGN OF BREAKWATERS.

By John Watt Sandeman, M. Inst. C. E.

The chief type of modern breakwater is that of a vertical wall, founded either upon the sea-bottom or upon a rubble mound. This primitive type of breakwater, consisting chiefly of an enormous mound of rubble, the stability of which is dependent upon continual inspection and renewal, may be considered obsolete, unless in sheltered situations, where the low cost of material would render such a type economical. This does not apply to the Italian type of mound-breakwater, protected on the sea face by blocks of concrete, which affects a large reduction in the volume of rubble. Breakwaters with long pitched slopes of masonry on their seaward side may also be considered obsolete, as vertical breakwaters effect the same purpose at less cost and more efficiency, by exposing less masonry to the action of the sea, and by reflecting instead of causing waves to break against them.

On comparing the proportions of vertical breakwaters which have stood in exposed situations, the majority have a mean breadth somewhat less than their total height, and there does not appear to be any instance of a vertical breakwater having been overturned by the sea, except where undermining had previously occurred. Failures have in all cases been due to undermining of foundation, either by removal of rubble, or by scouring of sea-bottom and consequent dislocation of uncemented blocks below low-water, or to defective concrete. In mound breakwaters with vertical superstructures, the risk of failure by undermining is greater when the top of the rubble is below low-water, but not deep enough to be clear of wave action, than when it is visible at each low tide.

Beyond a certain depth it is not necessary to increase the breadth of a vertical breakwater, as, assuming wave-impact to cease at about one wave depth, and seeing that the resultant of wave-force is near still-water level, there is a certain breadth of breakwater which, if continued parallel to any depth, will increase its moment of stability in exactly the same proportion as the moment of the wave-force is increased by the leverage due to increased depth.

Three types of construction may be adopted for vertical breakwaters, either upon rock or soft sea-bottoms, or for vertical superstructures upon rubble mounds, viz.: (1) For breakwaters having the greatest exposure, the most permanent type would be either a monolith of concrete, or a substructure of concrete in bags, with a superstructure either of concrete in mass or of large blocks cemented together.

(2) For certain situations and exposures, a structure of massive blocks sloping in direction of length of the breakwater would be more suitable. This type possesses the advantage of ensuring that all upper blocks impose their weight upon the lower ones. In the case of a long breakwater, Stoney's system of depositing blocks up to 350 tons weight by means of a floating derrick, might prove an economical, as it would certainly be a very stable, system of construction, seeing that a complete section of breakwater could be set in place at one operation.

(3) For breakwaters in less exposed situations and in comparatively shallow water, a structure of open timber piling of greenheart or creosoted pine, enclosing a filling of rubble, forms a stable and economical breakwater.

To ensure stability, the depth of the foundation of a vertical breakwater must be greater than the depth at which either a rubble-mound or the sea-bottom could be moved by the down-stroke and seaward-draft of reflected waves. This depth will vary according to the height of waves, height of breakwater, and size of rubble; but experience has shown that, in exposed situations, the depth at low-water over the top of the rubble mound should not be less than twice that of maximum waves, and the depth at which a soft sea-bottom would be moved would be considerably greater.

Breakwaters founded upon rubble mounds within the influence of wave-action have proved unstable, unless the rubble be continually renewed. Seeing that the stability of a breakwater is dependent upon the stability of its foundation, and the immobility of the blocks of which it is composed, and considering the failures which have occurred within the last 50 years, chiefly in breakwaters built upon rubble mounds and with uncemented blocks below low-water, it does not appear that the necessity for absolute rigidity in the foundation and under-water portions of breakwaters has hitherto been fully recognized; but considering the care which is exercised in the construction of foundations for bridges and for buildings on land, it may be asked why should not equal or greater care be exercised to ensure rigidity of foundation in structures which have to resist the violence of the waves? The works of lighthouse engineers are in this respect above criticism.

If the foregoing argument be admitted (and it has certainly been emphasized by the breaching of several costly breakwaters), then the remedy consists in providing rigid foundations at depths below the influence of wave-action, and in carrying up from such, either monoliths or massive blocks, each sufficient per se to resist displacement. In the case of a pier constructed of comparatively small blocks bonded in horizontal courses, but uncemented below low-water, it is impossible to have close joints and to build the blocks so that each will take its due share of load. The slightest settlement, therefore, upon a yielding foundation places an excess of weight upon some blocks and removes it from others; and, in consequence, the latter become loose and liable to be forced out of place by the reaction of air and water behind them.

Where a breakwater has to be built in comparatively shallow water, and on a sea-bottom of soft material extending to a great depth, two methods of construction may be adopted, viz.:

(1) Founding the breakwater in sections by means of caissons sunk to a depth greater than that at which the sea-bottom could be moved by reflected waves. (2) Dredging a trench and depositing rubble of depth sufficient to support the breakwater without settlement, the rubble having a depth over its top beyond the influence of wave-action.

In the case of a breakwater intended solely for sheltering purposes, cost may be considerably reduced by keeping its top low, as heights of from 3 ft. to 10 ft. above high-water, varying with the situation and exposure, are ample to annul the effect of all waves; and broken crests passing over the top would not vitiate the quietude of internal water-space. Reducing the height of the breakwater reduces the height to which waves are reflected, and the effect of their down-stroke and seaward draft. On top of a low breakwater, a deck, affording access to a lighthouse, is carried above wave-reach, either upon narrow piers or uprights of greenheart, or a subway within the breakwater effects the same purpose.

◆

Section III.—Machinery.

COMPOUND LOCOMOTIVES.

By Francis William Webb, M. Inst. C. E.

For many years the weight and speed of passenger trains had been continually on the increase, with the inevitable result of a demand for more powerful and faster locomotives to haul them. With the object of meeting these requirements, in 1878 the author turned his attention to the question of applying the compound system to the locomotive, and, as an experiment, converted one of the old engines belonging to the London & North-Western Railway Co. into a compound on the Mallet system, which he worked for about 5 years on the Ashby & Nuneaton Branch. The results were so satisfactory that the author was led to give further attention to the subject, the outcome of which was that he designed an entirely new system of applying the compound principle to locomotives, which enabled him, through the disposition of the cylinders, to dispense with coupling-rods without losing the advantages due to their use. He was also able to increase the size of the axle-bearings and other wearing parts beyond what was possible in an ordinary locomotive with single frames. In carrying out his system the author used two high-pressure cylinders and one low-pressure cylinder, the former being placed outside the frames and arranged to drive the back pair of wheels. and the latter was fixed between the frames and worked on to the front driving axle. The first engine constructed on this plan was built at Crewe Works in 1881-82, and named "Experiment." The high-pressure cylinders were 11½x24 ins., and the low-pressure cylinder was 26x24 ins., the valve gear used being Joy's. The driving-wheels were 6 ft. 6 ins. diameter. This engine was put to work on April 3, 1882, and the results obtained were so satisfactory that 29 more engines of the same type were afterwards built, the high-pressure cylinders, however, being increased to 13 ins. diameter.

As the requirements of the heavy traffic between Euston and Carlisle demanded still more powerful engines, the author, in 1884, designed and built the "Dreadnought." In this class the high-pressure cylinders are 14x24 ins., and the low-pressure cylinder 30x24 ins., the driving-wheels being 6 ft. 3 ins. diameter. The boiler pressure is 175 lbs. Forty engines of this class are now running.

To meet the increasing speed of the trains, the author, in 1889, built the "Teutonic" class. The cylinders being the same size as to the "Dreadnought" class, but the driving-wheels were increased to 7 ft. 1 in. diameter. In these engines the author simplified the low-pressure valve-gear by using a single eccentric instead of the "Joy" gear as heretofore. The arrangement consisted of a single loose eccentric on the crank-axle, which was free to turn on the axle into the correct positions for either "forward" or "backward" running, as required. The eccentric was connected to the low-pressure valve-spindle by means of a rocking lever, and was driven by a pin projecting from the side of the crank cheek, and engaging with a slotted plate forming part of the eccentric. The high-pressure valves are worked by Joy's gear. Ten engines of this class are running.

In 1891 the "Greater Britain" class was built, which the author specially designed for working the heavy and fast passenger traffic over the west coast route between Euston and Carlisle. The high-pressure cylinders are 15x24 ins. and the low-pressure cylinder 30x24 ins., the ordinary curved link motion being used for the high-pressure valves and a loose eccentric for the low. In this class both pairs of driving-wheels (which are 7 ft. 1 in. diameter) were placed in front of the firebox in order to obtain a more effective distribution of the weight on the driving-wheels. This arrangement necessitated a long boiler-barrel (18 ft. 6 ins.), and the tubes, which are 2⅛ ins. diameter outside, are divided into two lengths by a combustion chamber placed about midway in the length of the barrel. This chamber is fitted with a steam-blast apparatus for cleaning the soot out of the tubes. On Nov. 4, 1891, "Greater Britain" ran her trial trip from Crewe to London with a train of 25 empty coaches, at an average speed of 44½ miles per hour. Nine more engines of this class were afterwards built, one of which, the "Queen-Empress," was exhibited at the World's Fair, Chicago, in 1893.

It being thought desirable to increase the number of wagons in goods trains passing over the steeper gradients on some portions of the line, in 1893 the author designed and built an eight-wheeled coupled compound goods engine, with wheels 4 ft. 3 ins. in diameter. In this engine he arranged the cylinders somewhat differently to those in his other compounds, placing them all in a line under the smokebox, the high-pressure cylinders being outside, with their valve chests inside the frames, and the low-pressure cylinder within the frames, all driving on to the same axle, the second from the front. The high-pressure crank-pins were set at right angles to each other, the low-pressure cylinder being connected to a center crank set at an angle of 135° with the high-pressure crank-pins. Eighty-one of these engines are now running, and by their use a large number of "banking" and assisting engines have been dispensed with and the number of trains reduced.

In 1894 the author built the "John Hick" class, which was specially designed for working the heavy passenger trains over the steep inclines on the northern division of the North-Western Ry.

These engines are in all respects similar to the "Greater Britain" class, except that the driving wheels are only 6 ft. 3 ins. in diameter, instead of 7 ft. 1 in. Ten of these engines have been built.

The weight of passenger vehicles and the speed of trains being continually on the increase, it became necessary to provide still more powerful engines, and in 1897 the author designed and built the "Black Prince" class. These engines, unlike the other compounds previously built, have two high-pressure cylinders and two low-pressure cylinders, with a boiler pressure of 200 lbs. per sq. in. The former cylinders are 15 ins, and the latter 20½ ins. in diameter, both having a stroke of 24 ins. They are all placed in line, and drive onto one axle, this axle being coupled to the trailing axle behind the firebox. A feature of these engines is the method devised by the author for working the valves, two sets of valve-gear only being required for working the four valves. The valve-gear used is Joy's, which is applied to the low-pressure cylinders in the usual way. The low-pressure valve-spindles are prolonged through the front of the valve-chests, and each spindle is coupled up to a lever of the first order, which is carried on a pivot securely fixed to the frame, the other end of the lever being connected to the high-pressure valve-spindle. Thus the high-pressure valves are worked from the low-pressure motion, through the intervention of the lever, which is so proportioned as to give the required travel to the high-pressure valve.

In this class the author has succeeded in obtaining ample bearing surfaces throughout the engine, the driving axle having a central bearing in addition to the usual side bearings. The "Black Prince" ran its first trip on Aug. 2, 1897, and on the following October it commenced running on alternate days, the "Up-Dining Saloon Express," which left Crewe at 5:02 p. m., running through to Willesden, 152½ miles, without a stop, and returning to Crewe the same night with the "Scotch Sleeping Saloon Express," leaving Euston at 11:50, and running through to Crewe without a stop. Two of these engines are now running, and eighteen more are in course of construction.

As regards economy of fuel, from careful and exhaustive experiments made by the author, the saving due to compounding is about from 19 to 20%, and this is confirmed by observations made in the United States.

Compound Locomotives in Use on the London & North-Western Ry.

Class.	Date of design.	No. in service.	Total mileage to Feb. 28, 1889.	Ave. mileage per engine pr annum.	Coal consumption pr engine mile.*
"Experiment"	1881.	30	15,093,758	33,387	34.2
"Dreadnought" ...	1884.	40	18,681,936	37,206	39.4
"Teutonic"	1889.	10	5,193,126	58,241	37.9
"Greater Britain".	1891.	10	2,704,537	54,454	38,7
Freight	1893.	81	3,628,727	28,331	53.4
"John Hick"	1894.	10	629,180	48,868	44.8
"Black Prince"...	1897.	2†	190,324	57,820	40.3

*Average coal consumption per engine-mile includes fuel used for lighting fires and that used while engine is standing.

†Eighteen more are under construction.

Discussion.—The mileage and fuel records of Mr. Webb's various engines, which were embodied in the paper, we have compiled in tabular form herewith. Mr. B. H. Thwaite presented an offer from the Richmond Locomotive Works to send its famous "tramp compound" to England to be tried on English railways in competition with English built machines. It was objected that the clearance limits on English railways at tunnels, bridges and stations would prevent its running. English rolling stock is limited to a height of about 13 ft., and a width of about 9 ft.

THE RELATIVE ADVANTAGES OF DIFFERENT KINDS OF POWER FOR TRAMWAYS, LIGHT RAILWAYS AND MOTOR-CAR TRAFFIC, BOTH HEAVY AND LIGHT.

By Thomas Parker, M. Inst. C. E.

This paper presented so little of interest to American engineers that we omit it. The author's conclusions, briefly stated, were that electricity is the best system for street railways, that the cable is obsolete, and that the gas engine system is objectionable on account of the odors produced. For motor vehicles operated by storage batteries, he put the weight of the batteries at only 56 lbs. per HP. hour of available energy stored. In the discussion. Mr. John J. Thornycroft favored steam for heavy motor-vehicles. A builder of motor-wagons for carrying goods stated that his firm's vehicles had been running for six months, and had showed an average cost, including depreciation, interest, wages, fuel and all charges, of 6 cts. per ton-mile of goods carried. This figure was on the basis that the vehicle would have a life of six years, and would average 30,000 net ton-miles per year.

Another speaker stated that the street railway operated by gas motors at Blackpool, England, shows a cost of gas alone of 2.8 cts. per car mile (with gas costing 60 cts. per M. ft.), and the total operating expenses per car mile are 7.4 cts.

FORGINGS, AND THE MACHINES USED IN PRODUCING THEM.

By Edward Samuel Brett.

This paper discussed the extensive use of dies in the production of small forgings, and stated that recently dies had been made use of for producing large forgings on a scale hitherto unknown. In the shops of the London & North-Western and Great Western railways, a new system of die-forgings has recently been introduced, which bids fair to revolutionize the work:

> There is no doubt that in the near future the forged joints, links, pistons, connecting rods, etc., etc., will leave the smithing and forging department true to form and measure as required, with one-sixteenth or one-eighth inch, as the case may be, for facings, and no more.
>
> The elementary principles of this system are similar to those which have established themselves in die-forging small articles. Its main feature is a development in the way of power, in order to produce large forgings with dies, of equal quality to the small forgings hitherto made with dies.
>
> The vibration from blows of sufficient power and elasticity (or sharpness) to cause metal at a moderate heat to flow completely into the impressions of the dies, and to make clean work, are calculated to destroy any rigidly-built machine. In these machines, not any of the parts affected by the work are bolted together or anywise rigidly fixed; the guides are held and the dies set in position by flexible means—i. e., the lower end of each guide fits into a recess into the base-block, the top end passes up into a socket having sufficient clearance for wood packing; the wood is intended to absorb vibrations which pass up the guide rod.

MACHINE TOOLS: WITH SPECIAL REFERENCE TO AMERICAN AND GERMAN PRACTICE AS COMPARED WITH ENGLISH.

By Arthur Greenwood, M. Inst. C. E.

In introducing this subject for discussion, the writer proposes to divide machine tools into four classes, namely:

1. Planing machines, with which may be grouped shaping, slotting and machines used for cutting straight surfaces of metals with knife-edged tools by reciprocating motion.
2. Lathes and boring machines, for cutting circular surfaces of metals with similar knife-edged tools.
3. Milling machines, for cutting straight or curvilinear surfaces of metals with circular rotary saw-like cutters.
4. Automatic machine tools, for special purposes.

It is upon the planing machines that the engineer relies as the basis in mechanical construction, the first requirement being a true flat surface; secondly, speed in obtaining that result; and, thirdly, economy in wear and tear and facility of maintenance in an efficient state. Strength and rigidity are the main factors in obtaining these results. These being assumed, there has to be considered what is the best form of bed surface, the best section of cross-slide, and the best driving-gear.

In the earliest planers, acute V surfaces were used, doubtless to resist the strain of side-cuts and to take up the wear automatically. These V's, of from 60° to 90°, have been gradually flattened, with beneficial results as regards scoring, until 140° is a common practice; but all V's are difficult to make a good job in the first instance, and still more difficult to correct when by wear they become hollow or assume a "wind." The latest practice is to use flat surfaces with square or angular lips, and taking up slips to take the side strains. They much more easily effect a thoroughly good job in the first instance, as bed and table can be scraped to surface-plate independently, and are much more readily tested and readjusted when in use. The flat bed is gradually being adopted in England, and, to a less extent, in America and on the Continent, but even here the prejudice in favor of V beds dies hard. In some dozen large planers just completed or under construction by the writer's firm, V's have been specified by the purchasers in most cases, sometimes with a central flat surface; only in two or three cases have the makers been allowed to carry out their recommendation of flat surfaces alone.

The latest practice in cross-slides is the square lip on the upper side, certainly in America, and to some extent in this country, particularly for heavy machines. Much has been attempted in the past to make planers duplex in their action, either by reversing the tool or arranging the machines with two sets of uprights and cross-slides so as to cut in both directions; either method obviously can only be used with advantage in plain surface work, and both systems are seen more in England than in America or Germany. To economize time in running back, the Americans are leading the wary by using very quick return of table up to and even beyond four times the cutting speed. This entails very perfect gearing and accurate reversing gear, friction clutches being often used; it absorbs, at any rate momentarily, a large amount of power, as those using electric driving can readily see by watching the ammeter.

For driving gear in this country, the screw is much in favor; it works smoothly and simplifies the gearing, but is not quite so economical in power as well-adjusted rack gearing. The Americans generally prefer rack gearing, and are obtaining splendid results with engine-cut fine-pitched gear. The compromise between the screw and the rack originated by Sellers in the States is largely used there, and has been followed by some English and German makers. Unless the gearing is very accurately pitched, there is a material increase in the power used. The most economical planer for general work would appear to be the single-acting machine, with a very high speed of return, and a most accurate reversing gear easily adjusted whilst the machine is running, so as to reduce the idle time of the machine to a minimum.

Lathes.—In England the upright V, generally in conjunction with a flat, was originally used for lathe beds. Now, however, flat-surfaced beds with angular edges, or, as they are sometimes called, "gib" beds, are almost invariably used, being generally considered more robust and more readily kept in repair. The Americans, however, with one or two notable exceptions, adhere to the upright V, generally double, and this constitutes the leading difference beween Eastern and Western lathes. The saddle mounted on the V's moves with less friction, but for heavy cuts this advantage is lost, as the saddle must be weighted or retained by a lip to prevent the cutting tool running in.

As regards headstock and spindle, the parallel neck is more used in the States than in this country, where conical necks are generally used for small lathes and parallel ones for the heavier ones. Cones and belts for traverse gear are now being generally discarded in favor of direct gearing both in England and in the States, and the lathe headstock of the future, with a variable speeded electric motor combined, will soon see the end of belt-driving, at any rate so far as lathes are concerned. In lathes generally the Germans follow more closely the English than the American type.

Before leaving lathes, one must remark the very general adoption, particularly in America, of the horizontal face-lathe or boring mill, which offers facilities both for speed and accuracy. Turret lathes may be grouped with automatic machinery.

Milling.—This is one of the earliest known ways of cutting metal, doubtless temporarily eclipsed by the development of planers and tools under Class 1. Both in America and in this country, manufacturers of articles where great repetition occurs, such as rifles, sewing and some textile machinery, have used milling for the past forty or fifty years, and the development of this system of cutting metal, as seen in the modern universal miller in a well-equipped tool-room, leaves little to be desired for rapidity, accuracy and general adaptability. During the past fifteen years milling machines have been largely introduced for heavy work, notably for locomotive and engine builders, and in this direction English makers have certainly been to the fore. Some of the continental makers have carried milling to questionable lengths, particularly in France, where one has seen work being milled which might have been more advantageously done on planing machines. In England and America, and in France, vertical millers are principally used for plain and curvilinear work. Many are also made on the planing machine type with either horizontal or vertical spindles, or both. This is an excellent type of machine, particularly for straight work. The Germans often go to the length of combining this type of machine with a planer, but as a rule combination machines are to be avoided.

Automatic machinery for special purposes is now coming very much to the front, chiefly in America, but both this country and Germany are moving in the same direction. Where great repetition of parts is required, there can be no doubt of its advantage. A general type of machine is a hollow spindle lathe with automatic feed and chuck for the material to be operated upon, a saddle with turret rest, back and front transverse slides, all driven automatically from a cam shaft. This machine will produce studs, screws, bolts and other analogous work from the solid metal bar. By using special chucks, wheels, pulleys, cylinder-covers and other parts of engines or machinery may be finished at one fixing, as against innumerable chuckings in the ordinary boring and turning lathes. The advantages claimed for this system are that a comparatively unskilled operator may attend to a number of machines, the tools and tool-adjustment being controlled by a skilled mechanic. The enormous advantage of this system of manufacture must not be sacrificed by attempting to do too much, and discrimination is required to see that work which can be better done by separate operations is not attempted on this class of tool. In turning work from the bar, such as studs, bolts, etc., care must be taken that the advantages gained by saving of labor is not lost by waste of material, and articles having large differences in diameter may often be advantageously forged and finished in other types of automatic or other lathes.

Now that the gearing of nearly all machine tools is engine cut, automatic gear-cutters are largely used. One attendant serves quite a number of machines.

In machine tools generally, with some recent exceptions, the Germans have followed pretty closely the English lines, but have produced cheaper and lighter tools, and have lacked in originality. The Americans, on the other hand, have struck out on lines of their own, based on those of some of the earlier English makers. They are generally well-made, convenient to manipulate, but of lighter construction, and have not the endurance of the English tools.

The English tool-makers for a long time were practically the makers for the world. For strength, stability and downright wearing capacity, they still hold the first place; the one reproach that may be made against them is their comparative slowness in producing tools required to meet the growing and changing requirements of the trade, which gives the Americans a certain pre-eminence. Probably one of the reasons is that here tool-makers attempt too many varieties. Nearly every maker produces all the various classes, whilst in America they generally confine themselves to one. Whether this is arrived at by mutual arrangement, or is the result of their practical nature, the result is satisfactory in producing machine tools of standard sizes suited to the requirements of the hour, and, by reason of this standardization, at an economical cost.

"SEPARATE CONDENSING PLANTS FOR FACTORY PURPOSES."

By Sir Alfred Seale Haslam.

This paper discussed in an elementary way the four different types of condensers. Injection, ejector, submerged or surface condenser, and evaporative condenser. The first is the oldest and is simple and cheap. The second is the cheapest of all, but requires careful adjustment and gives only 14 ins. to 18 ins. vacuum. The surface condenser is the best but also the most expensive. The evaporative condenser is only used where the supply of condensing water is limited. The fuel economy due to condensing is 20 to 30%.

CRANES AND THE POWER TO BE USED WITH THEM.

By Walter Pitt, M. Inst. C. E.

The steam crane is undoubtedly the best type to use where only a single crane is required, or where several portable cranes have to be dealt with whose relative positions may be altered within wide limits, or which may at some future date be transferred to another site. It is simple to work, as economical as most of its rivals, ready at short notice, and requires little permanent work for its installation except in the larger sizes of fixed cranes. When, however, it is a case of an overhead traveler or several fixed cranes, or a number of portable cranes with a limited range of travel, then the consideration of other motive power than steam at once begins.

Shaft-driven overhead-traveling cranes work very well where the motive power is not too far away, but they have disadvantages. The loss in friction is probably the greatest of all systems; the speed at which the transmitting organ (the shaft) can be driven is necessarily very limited, and the tumbler bearings are always inclined to be troublesome.

For conveying power by direct mechanical means, it may be considered an axiom that a quick light drive always to be preferred to a slow heavy one, and therefore it was a decided step in advance when the quick-running rope-crane came in, and by a process of the survival of the fittest settled down into the well-known type in which the driver sits in a cage below the girders and actuates the machine by shifting open and crossed belts, the speed reduction being made at the crab by worm and wheel.

The introduction of the electric transmission of power marked a noteworthy departure in crane design, and solved in a very satisfactory manner all the difficulties previously experienced in taking the power from the motor to the crane. Electric leads are easy to erect, noiseless, motionless, cheap, and by their means power can be conveyed along routes that would be quite impracticable by any other means, and with very considerable economy. The author puts the latter point last, because although users much appreciate economy, they appreciate convenience a great deal more. Speed and convenience of working take precedence even of coal consumption.

The first electric cranes and travelers were worked by a single motor often kept running continuously, and the various motions were obtained by shifting belts or other forms of friction clutches. Latterly the practice has been to use a separate motor for each motion. Having got so far, a lesson was taken from tramway practice, and series-wound motors were used instead of the self-governing shunt-wound motor previously necessary.

The series-wound motor, with its big starting torque and its capability of responding to the drivers' views as to speed, has much analogy to the engines of a steam-crane regulated by the drivers' hand on the starting valve, and the writer thinks that it is precisely this possibility of using series-wound motors that is the great advantage of the single motor machines. Jib cranes are usually now constructed as two motor machines, one for lifting and one for slueing. The subsidiary motions of jib derricking and traveling are less often used, and can be well worked from the slueing motor by a change of gear.

The reduction of speed from motor to first motion shaft has been effected in every possible manner. Practically two methods survive, worms and cut-gear. The much-despised worm is noiseless, and very convenient to apply in many cases and, if properly designed, even a worm will turn, and that with a very respectable efficiency. The author would remark in this connection that the ordinary formulas for worms will, if used with proper coefficients of friction, give results well borne out by practice. The next inportant organ in an electric crane is the controlling gear. Here the tendency has been lately to adopt liquid resistances, and still more recently to use controllers which are practically tramcar controllers. It is a striking feature of electric crane design that whereas at first the old power traveler was the model, the tendency is now to go to tramway practice, and there are, in fact, many points of analogy between crane and tramway work, especially in all that concerns the starting and accelerating conditions. In Germany considerable attention has been paid to the problem of recovering the energy lost in lowering the load by generating current in the motor. Many of these arrangements are very interesting, but the writer doubts whether here again efficiency of doing the work required does not take precedence of current consumption, and for quick lowering nothing beats a free barrel controlled by a foot-brake.

The hydraulic crane is too well known to require long notice here, it will probably be always with us, but the electric crane will be a very serious rival. The electric crane itself is more expensive, but the generating and transmitting plant are less costly. Electric cranes are not effected by frost, and they also have the good point that the maintenance repairs are generally within the competency of the man who looks after the crane.

Section IV.—Mining and Metallurgy.

THE INFLUENCE OF CASTING-TEMPERATURE UPON STEEL.

By Robert Abbott Hadfield, M. Inst. C. E.

This question is especially surrounded with difficulties on account of the fact that the casting-temperature of steel is only known approximately, even with the latest form of pyrometers. Useful work has been carried out in France with the Noel and Mesuré optical pyrometer, but while it is claimed that much has been learned from its use, at the best it only gives approximate results. Seeing that Mr. H. H. Campbell, in his excellent paper on "The Open-Hearth Process" (American Institution of Mining Engineers, 1895), states that even a difference of 20° to 30° C. causes considerable changes in the behavior of molten steel during casting, it will be understood how important it is that a thoroughly practical pyrometer, which would enable us to detect such differences, should be perfected. Mr. Campbell's remarks on this subject are so important that it may be well to quote them fully. He states that an addition of 100 lbs. of scrap to a 7-ton bath $\left[\frac{100\text{ lbs.}}{15{,}700\text{ lbs.}}\right]$ will cause the temperature to fall about 16° or 20° C., and that this variation is perceptible to the naked eye.

An excess or deficit of $\left\{\frac{500\text{ lbs.}}{15{,}000\text{ lbs.}}\right\}$ in the addition of scrap on the same weight and heat makes the charge either so hot that it causes trouble, or so cold that it skulls badly in the ladle. A variation of 200 lbs. from the true amount, which would show by calculation a variation of about 30° C., is the greatest error allowable in good practice.

Incredible as it may seem, within these narrow limits lies the success of the blower and the melter. Perhaps the best practical pyrometer available, naturally varying according to individual circumstances, is practical observation by the eye, as there are no absolutely correct data as to the temperature at which steel should be cast. If steel is cast too hot the ingots or castings are liable to be piped considerably, even though the utmost care be used in pouring, and there are other difficulties such as segregation. If cast too cold the metal produced will not work as satisfactorily as it should do during forging, and the ingots will probably be round and unsatisfactory on the exterior.

A very peculiar appearance is noted in crucible steel which is cast too hot; it is usually known as "scalded" steel. The crystalline structure is very pronounced, but by careful reheating the peculiar appearance noticed seems to disappear, though it is questionable whether the product is even then entirely satisfactory. In a recent correspondence of the writer with Messrs. Huntsman, of Sheffield, who still carry on the manufacture of crucible cast-steel, founded by the well-known inventor, Benjamin Huntsman, in 1740, it was stated that to obtain the best quality, scalded steel could never be re-treated except by re-melting. It will be seen, therefore, that the greatest possible care should be taken to have the steel prepared during its course of manufacture in such a way as to obtain the happy medium of temperature, that is, neither too hot nor too cold, but until more perfect pyrometers are produced this can only be obtained with constant liability to error.

TABLE I.—Showing Colors of Steel at Various Temperatures from 650° to 1,300°

Color.	Temp., deg. Cent.	Color.	Temp., deg. Cent.
Hadfield.			
White*	1,240	Bright red	923
High yellow	1,130	Medium red	795
Yellow	1,081	Blood red	667
Low yellow	971		
Pouillet.		Bowker.	
White	1,300	White	1,204
Orange heat	1,100	Very bright red	1,010
Cherry red	800	Bright red	926
Red heat	525	Full red	804
		Red heat	650

*Not welding heat.

The table of temperatures, Table I., has been found very useful by the writer in everyday work. The first part represents the author's results obtained by means of a Le Chatelier pyrometer suitably protected in the furnace; this pyrometer is an admirable one so long as it does not come in contact with molten metal. Part two represents similar comparative temperatures taken from Pouillet's Tables, and part three is from a table prepared by an American expert. There is also added in Table II. the melting points of various metals, also the temperatures noticed during industrial operations obtained by Mr. H. le Chatelier and others, both with electrical and optical pyrometers; these are in some cases necessarily approximate for the reasons before given.

TABLE II.—Temperatures in Degrees Centigrade of Melting Points of Various Materials.

		Cent. Degs.
Melting point of	Sulphur	448
	Gold	1,045
	Palladium	1,500
	Platinum	1,775
	White swedish (4% carbon)	1,135
	Gray foundry iron (3½% C, 1¾% Si, ½% P.)	1,220
	Soft steel (0.10%C)	1,475
	Hard steel (0.30% C)	1,455
	Hard steel (0.90% C)	1,410
6-ton converter..	In the ladle	1,640
	In the ingot mold	1,580
	Re-heating furnace	1,200
	Ingot under steam-hammer	1,080
Siemens-Martin furnace (steel containing about 0.30% C): End of fusion-period of cast-iron.		1,420
Refining point of the steel		1,500
Steel in the ladle (commencement)		1,580
Steel in the ladel (end)		1,490
Temperature of gas from producer		720
At the entrance to the regenerator		1,400
When leaving the regenerator		1,200
When arriving at the chimney stack		300
Siemens-Martin furnace		1,600
Rotating puddling-furnace		1,230 to 1,330
Blast furnace w'rk'g on gray Bessemer near tuyeres		1,930
Commencement of the blast		1,400
End of the blast		1,570

MODERN IMPROVEMENTS IN COAL-MINING: WINDING FROM DEEP MINES.

By Henry William Martin, M. Inst. C. E.

There are few more important or difficult problems to be solved, in connection with coal-mining at great depths, than that of winding or raising the coal through the shafts. Engines are constructed capable of developing much greater power than is required for colliery winding, but to perform the work economically, in the intermittent manner rapid winding demands, there is still much room for improvement.

The motive power developed by the engine is expended in raising the useful load of minerals, in overcoming the frictional resistances of the winding apparatus, and in communicating velocity to all the moving parts. When the speed is low, the power expended in the latter way is small; when high it is considerable, but should be utilized in assisting to raise the load, and to overcome the frictional resistances before the wind is completed, but a large portion is frequently expended in friction on the brake. An important object in the design of winding machinery is to make the demands on the power of the engine as nearly uniform as possible. Many devices are resorted to in order to obtain this object, and are more or less successful. Two only will be instanced here, viz.: (1.) The employment of a balance rope. (2.) The adoption of a drum of varying radii, generally of a conical form.

Both of these appliances are well known, and have long been in use. Balance ropes for deep windings, however, have not been very extensively adopted, and where used have not always been successful, although they are now more or less returning to favor. The objections urged against this arrangement are the extra strains on the caps or sockets of the winding ropes and the increase of friction due to their weight, but the greatest difficulty probably has been found in guiding the balance rope at its return at the bottom of the shaft. Pulleys revolving in sliding bearings and other means have been used for this purpose, but the author considers the most effective method, and the one he adopted, is to use a specially made flexible and untwisting steel wire-rope guided sidewise at the return by two vertical parallel plane surfaces only, between which the rope is allowed to assume a free path. The radii of drums are often more or less proportioned, so that the moments of resistance due to the load are constant throughout the wind, and this arrangement is very extensively used, with considerable success. It is, however, high in first cost, and there is an increase of friction due to the extra weight of the drum. There is also a larger mass to be set in motion and brought to rest than is the case with a cylindrical drum and a balance rope.

MODERN PRACTICE IN GOLD-MINING.

By John Hays Hammond.

Problems in mining may be classified as those relating to: (1) Mining Geology; (2) Mining Engineering; (3) Metallurgy; (4) Mechanical Engineering. In the last class are the problems pertaining to the installation of mining machinery. The problem of deep mining likewise belongs to this class. The factors determining the limit to which deep mining may be carried are: (1) Depths per se; i. e., costs of deep shafts and of haulage; (2) ventilation; (3) drainage.

(1) Depths per se.—From an engineering point of view mining could be carried on at depths which considerations of an economic nature would preclude. With the existing types of hauling-engines, wire-cables, etc., there is no difficulty in hauling through vertical shafts from depths of 6,000 ft. An improvement in types of engines and appurtenant machinery, which is undoubtedly within the power of the engineer, would enable this depth to be considerably increased. From the bottom of the vertical shaft an incline shaft, or a second vertical shaft, could be sunk to a vertical depth, of say 4,000 ft., giving thus a total depth of 10,000 ft. Such depths increase greatly the first cost of operations, in that they involve a corresponding increase in the size of the plant required for shaft sinking, for hauling, mining material, miners and ore, in addition to the cost of the shaft itself. The actual extra cost per ton of ore, etc., hauled would not be excessive, and would not greatly militate against profitable mining, unless the margin between profit and loss had already become a narrow one in the shallow levels.

(2) Ventilation.—One of the great obstacles to deep mining is the difficulty of securing the requisite efficiency of ventilation, due to the increase of heat in the workings as depth is attained. The heat encountered in mine workings may be due to one or to a combination of two or more of the following causes: (1) The increasing secular heat as the interior of the earth is approached; (2) proximity of the mine workings to regions of heated volcanic rocks, solfataras hot springs, etc.; (3) chemical decomposition of certain constituents of the ores, or of the enclosing wall-rocks, confined to deposits of comparatively rare occurrence; (4) animal heat and heat due to use of illuminants and explosives, all of subordinate importance.

Geologists estimate as the result of deep bore-holes and other tests, that the average increment of temperature due to internal heat of the earth is 1°F. for about 60 ft. vertical depth. The rate of increase in different localities is by no means uniform, sometimes being as low as 1°F. in upwards of 250 ft. vertical depth. Indeed, in the same mine, the increment of temperature is not invariable, though generally it is fairly constant in some mines, indeed, remarkably so. The isogeotherms are chiefly affected by the proximity of regions of solfataric action or other volcanic phenomena, and by the conductivity of the rocks in which they lie.

If 1° in 60 ft. be accepted as the average increment of temperature, there will be an increase of 16° per 1,000 ft. vertical equivalent to 80° at a depth of a mile. Assuming the normal surface temperature to be 60°F., this would give a temperature of 140°F., one by no means insuperable, but at the same time not economical. To counteract the effects of this undue temperature, artificial ventilation is requisite. Under very favorable conditions the cost of the necessary artificial ventilation in metal mines, especially where inflammable and noxious gases are of rare occurrence, would not preclude mining to depths of 10,000 ft. Nevertheless, high temperatures, even when not intolerable, entail extra expense, due to the fact that the miners are thereby more or less incapacitated. Under these conditions short shifts are adopted, and not only artificial ventilation, but also the frequent use of iced drinks, cold baths, etc., are necessary.

(3) Drainage.—This is one of the least determinable factors. The water pumped from mines is sometimes almost exclusively limited, even in workings of considerable depths, to the upper levels of the mines. On the contrary, however, there is sometimes a progressive increase in the water as depth is attained. This increase is by no means constant, and generally varies considerably from level to level, depending upon the character of the ground drained by underground developments. Where there is an abnormal influx in depth, the expense of pumping becomes a menace to profitable mining operations, though under normal conditions this increased cost may not prove an insuperable factor.

The extra cost of deep mining, as has been indicated, is chiefly due to longer haulage, etc., to increased cost of drainage and of ventilation. In the working costs of shallow mines, or of those of moderate depths, these items are small compared with the total cost, in which are included general expenses, costs of development, stoping, metallurgical treatment, etc. Therefore, the additional cost of mining in depth entailed by these factors could be considerably increased before reaching a sum which would make deeper mining unprofitable. The factors, then, which determine the limit of deep mining, and by deep mining depths of 4,000 ft. and upwards are referred to, are: (1) The discontinuance, or, what is tantamount, the impoverishment of the ore-deposit. This, irrespective of other considerations, is the cause of the cessation of deep mining operations in the majority of cases; (2) the excessive costs of first plant, of ventilation and drainage under unfavorable conditions. This applies especially to the exploitation of ore-deposits, where the margin between profit and loss is close; (3) difficulties of a purely engineering nature.

NOTES UPON SOME OF THE MECHANICAL PROBLEMS PRESENTING THEMSELVES TO MINING ENGINEERS WITH SPECIAL REFERNCE TO GOLD-MINING IN THE TRANSVAAL.

By Fearnside Irvine, Assoc. M. Inst. C. E.

Mine Pumping: Sinking Pumps.—Pumping from the bottom of the shaft in sinking is seldom resorted to unless under absolute necessity, the water being generally pumped or baled into the skip and hoisted to the pumping station above. When sinking-pumps are used they are suspended in the shaft, being hoisted up and lowered again at each blast. They are heavy, clumsy and troublesome, and are best operated by compressed air. A handy and efficient sinking-pump is much wanted.

Station-Pumps.—For deep-level pumping, and especially where the shaft is first vertical and then inclined, the Cornish pump is not suitable, and electrically-driven pumps, either the three-throw vertical plunger, slow running type with ordinary valves, or the three-throw vertical fast-running Reedler, are rapidly replacing it. Their efficiency for moderate lifts may not be so high as that of the Cornish pump; but, unlike the latter, it does not decrease with the depth, and the cost of installing an electric plant is so much less that the interest on capital saved more than makes up for any difference even at first.

It has been said that when the water rises to an electric pump it must stop, while the Cornish pump can go on working. A Cornish pump, however, cannot work for long under water, and if the water does not soon fall, auxiliary pumping must be resorted to. In both cases the skips are available at once. In a gold mine the main station electric pump would never be placed on the bottom level in a wet mine, and in all cases the mine can be safeguarded by making the pumps of ample capacity and trusting the rest to the skips.

Deep-Level Hoisting.—The limit of deep-level hoisting not very long ago was about 3,000 feet vertical; and at this depth a drum to contain all the round rope necessary without overlaying was neither large nor inconvenient. Now, however, the requirements of mining demand not only that much greater depths shall be reached, but that the winding speed shall be greatly increased.

The manufacture of high-class wire ropes has now made it possible to reach the depths required without intermediate hauling-stations, and the engineer is called upon to provide a hauling machine and subsidiary appliances, both below and above ground, which shall make it possible to take the fullest advantage of this fact.

Flat ropes, wound on themselves in a reel, are used successfully in vertical shafts; the reels take little lateral space, and the rope is thus easily kept central to the hauling compartments; but they are bigger in diameter than those required for round rope, while for greater depths the extra weight of the flat rope soon puts it out of court. The wear and tear on them is much greater than on round rope, and they are inadmissible on inclines. The width of drum required is the great drawback to the use of round ropes for great depths, causing, as it does, the hauling rope to make a large angle with the sheave on the headgear. To get over this difficulty and others pertaining to these large drums, several systems have been devised, viz.: that of Koepe, in which the rope is simply led round a driving pulley, making a little more than half a turn on it, being led thence over the two headgear sheaves and down the two compartments of the shaft; a tail rope is used, fastened to the bottom of the skips, the whole being worked in balance. Another system, that of Whiting, has been tried on the Lake Superior copper mines and on the Rand. It consists of two pulleys, or drums, one behind the other, the rope from the shaft going round both several times, being then led to a tension-pulley behind the engine-room, round which it passes, and thence over the sheave and down the other compartment of the shaft. Changes of level are easily effected by running the tension-pulley in and out on a track provided for it.

Having thus far discussed the question of the drum only, it might be well now to take up that of the motive power. As yet, the steam engine has full possession of the field as a motor for heavy winding machinery; but the merits of the electric motor are such, and its claims as an efficient motive power for this class of work so great, that it should soon begin to displace the steam engine in this respect. The motor can be mounted on the drum-shaft direct, doing away with all the complicated gear of the steam engine. Each motor would require to be able to haul the empty skip when at its lowest level, the two motors and drums being coupled by a friction-clutch on the middle of the shaft, all other clutches being done away with. Each motor would act as an electric brake to the other in lowering.

In a steam engine half its power is only available to start the load, but in the electric motor the whole power is at once applied. With the electric motors, wear and tear, and, therefore, repairs, would be less, and, with a proper installation, the cost of fuel also.

Air-Compressors.—The transmission of power by compressed air is not nearly so efficient as by electricity, and its employment on a mine should be confined to purposes for which it is absolutely essential; these are rock-drilling and the operation of emergency and sinking-pumps. No electrical drill has yet succeeded in supplanting the air drill, and no electrical pump is handy enough or, indeed, would stand shaft-sinking conditions. Drills have an efficiency of from 35% to 40% of the power developed by the steam end of the compressor, pumps 18% to 22%.

Ventilation.—Ventilation should be done by an exhaust-fan in the upcast shaft, supplemented by electrically-driven fans underground and the discharge of rock-drills.

Mine Signaling.—This requires more attention, especially in mines having many working levels, and where sinking is going on at the bottom of the shaft while hauling is being done in the upper levels. A combination of the electric signaling apparatus used from the bridge to the engine-room on ships with a separate bell signal, as is now in common use, arranged on two independent circuits with a common return, would seem to answer best.

Handling the Rock at surface and sorting.—This is done by tipping the rock over grizzlies, making three classes; the coarsest is conveyed to the rock-house and picked or sorted by hand on a revolving sorting-table; it then gets a preliminary crushing, is picked again on another table along with the second product, broken fine, and sent to mill. The fines are taken to the mill from the headgear direct. More automatic machinery is wanted in this department.

Rock-Breaking.—Breakers are of two kinds, reciprocating and rotary. The rotary ones crush more rock per horse-power, while the reciprocating cost less for repairs. Improvements are needed to both, but especially to the rotary crusher, to bring them up to modern requirements.

Hauling Rock to Mill.—Various methods, such as inclines with endless rope or chain, or tail rope haulage, more or less automatic elevators and winding drums, supplemented by hand-trucking, are used for this purpose, but no completely automatic method has yet been introduced for this work.

Milling.—Of late years milling has been much improved by gradually bringing what was a few years ago one of the most slipshod and neglected branches abreast with the requirements of modern mechanical science. The crushing power of the gravitation-stamp has been raised from 2 tons to 6 tons per head, and a much greater mechanical efficiency attained, viz., about 92%.

In the Treatment of Tailings.—To elevate the sand and water escaping from the mill, bucket-elevators, centrifugal pumps, plunger-pumps, pulsometers, and elevator-wheels, were all tried. After passing through many different stages of development the plunger-pump and the elevator-wheel alone survive. The wheel being much the most economical in maintenance and efficiency is used for lifts up to 48 ft., beyond which the pump, if specially constructed, will probably be best. In carrying out tailings work, great difficulty was and is experienced in determining the size of launders and classifiers, and, in fact, with all the hydraulic apparatus, from the want of exact figures upon the carrying power of water; the tailing sands vary greatly in specific gravity, and the grade which gives velocity enough for the tailings of one mine does not do for another, while the additional area required in the launder to compensate for the retarding effect of the sands seems never to have been exactly determined. The methods of discharging tailings, which amount to 30,000 tons daily, is another problem awaiting satisfactory solution. It should be as nearly as possible automatic, or at least, after the truck has been hitched on to the haulage-rope, it should go out, be dumped, and return empty. This has not yet been successfully effected.

Treatment of Slimes.—This part of the product of the mill, after being reduced from 97 parts water and 3 solid matter to 3 water and 2 solid matter, is handled by centrifugal pumps and pumped in and out of large settling tanks, in which five or six times its weight of cyanide liquor is first added to it to dissolve the gold; and then, after the gold is dissolved, this cyanide liquor is separated from the solid matter by decantation, and it is the difficulty of effectually doing this which constitutes the principal trouble in the slimes treatment.

Precipitation of the Gold from Cyanide Liquors.—This is effected by running the gold solution into a tank in which the metal is precipitated by the electrolytic action set up by the action of the solution on zinc shavings or by forcing a current of electricity through the solution from an outside source. The zinc method is the cheapest and has on the whole proved itself the most effectual.

◆

Section VI.—Water-Works, Sewerage and Gas-Works.

SEWAGE-SLUDGE DISPOSAL BY NATURAL AGENCIES.

By G. Sims Woodhead, M.D.

In this matter of sewage-sludge disposal is practically involved the crux of the sewage question, as from recent investigations and experiments it has been proved that it is a comparatively easy matter to bring about disintegration of organic matter held in solution, especially if the solution be sufficiently dilute. The proportion of sewage matter held in suspension to that in solution is comparatively small, but owing to the fact that it is solid, there has been a difficulty in dealing with it, unless it could be removed from the sewage by sedimentation, precipitation and screening, and buried, when the organisms of the "living" soil very rapidly bring about its breaking up. It has, of course, to be borne in mind that sewage-sludge consists almost entirely of organic matter, and that if any large amount of inorganic matter finds its way into sewage, that it is from road surfaces or from yards, or is washed from the surface of loose soil. Such inorganic matter can only be got rid of by sedimentation, and unless it is got rid of we can never hope to deal successfully with the sludge, as no means of disintegration at present known will deal with quartz or clay, and the presence of these substances, especially the latter, must necessarily interfere greatly with any process of bacterial disintegration that has hitherto been devised.

With organic solid matter it is, however, I believe, perfectly possible to obtain good results. In nature, organic matter is dealt with not only in the soil, but on the surface of the soil. If any organic matter be left exposed, on a gravel surface say, it will be observed that, although there may be a hard outer film formed in dry weather, as in the case of a mass of cow-dung, the center at first moist, in time becomes exceedingly soft, and gradually diminishes in quantity, so that when rain comes such a mass of cow-dung, though hard on the outer surface, is very rapidly washed away. In showery weather, the process goes on with even greater rapidity.

What takes place under these conditions? First of all we have in the moist mass an enormous development of anaerobic organisms which, utilizing some of the material as food, produces a series of substances which have the power of digesting and dissolving a considerable portion of

> the organic matter. In this process we have also produced gaseous and liquid substances, the former of which escape into the atmosphere, often giving rise to foul smells; the latter soak into the soil, there being attacked by other organisms. In wet weather, or when the mass remains moist, we have in addition the action of a series of aerobic organisms brought into play; these assist in the oxidation of the products formed by the organisms in the substance of the mass. Under these conditions, there is a more free escape of the gaseous products, and a washing away of those products which interfere with the activity of the micro-organisms. In fact, all the soluble matter is washed away, and the mass of dung disappears, comparatively rapidly. If this mass of fæces be buried in the soil, the process may go on still more rapidly, and it will be found that the vile smelling gases are so rapidly oxidized by the aerobic organisms that grow near the surface of a porous soil that not a trace of odor is met with.
>
> All the methods of treating the solid matter of sewage that hitherto have achieved any success are those in which these processes of nature have been applied under controlled conditions, which, of course, must to a certain extent be artificial. But the nearer these can be brought to the conditions observed in nature, the more successful will they be in getting rid of or of disintegrating solid organic matter. In a cesspool, which, as we know, seldom requires to be cleared out, the solid substances of sewage is gradually but surely disintegrated; but the great disadvantage of the cesspool is that the enormous amount of gas formed must find its way out somewhere, whilst, as the substances become liquid, we have leakages into the soil in all directions, so that a large quantity of imperfectly oxidized material accumulates in the neighborhood of the tank, the sodden ground allowing of no aeration.
>
> In the disintegration tank of Scott-Moncrieff and in the Exeter septic tank, the main part of the work done is this disintegration of solid material by anaerobic bacterial agencies. The solid material remains sufficiently long in contact with micro-organisms to be broken down—in fact, it remains there until it is broken down. There is this additional advantage, that there is constantly flowing over the surface of the breaking down sludge a fluid in which the gases are dissolved as they rise from the decomposing organic matter, and which carries away a large proportion of the products of the life activity of these micro-organisms; the organisms are thus left free, ridded as they are of the effete products to which they give rise, to go on with their work energetically; indeed, this flow of water acts, to a certain extent, as does a shower of rain, except that the sewage does not contain oxygen, whilst the rain does. It is, of course, impossible for oxidation to go on at this stage in a septic tank, say, and, therefore, without special arrangements, offensive smells may be developed. As soon, however, as oxidation commences, as it must wherever aerobic organisms are able to live, we have a rapid transformation of these offensive gases into non-smelling gases, very frequently of much simpler composition, but always containing a considerable proportion of oxygen.
>
> I maintain that the question of the disposal of solid organic matter, or sewage-slude, must go on in these artificial tanks as nearly as possible under the conditions met with in nature if the process is to be successful. We must bring about rapid disintegration by anaerobic organisms, wash away all soluble and gaseous matter as soon as formed, and submit these to aeration, oxidation, and the action of aerobic organisms. Only thus can we best deal with the solid matter of sewage. By sedimentation in catch-chambers, separate out, as far as possible, all inorganic material. In the case of clay, it is very difficult to do this, and the better plan, therefore, is to prevent, as far as possible, unsedimented surface water from getting into the sewage. It does not matter how concentrated the material to be acted upon may be, but it is very important that the supernatant fluid should not contain too large a proportion of organic matter on the one hand, and that, on the other, it should not contain too large a quantity of effete products—ammonias, methylamines, and the like, which interfere with the action of the anaerobic organisms, no organisms being able to do their work in the presence of too large quantities of their own effete products.
>
> How far the rapidity of oxidation may be increased by the use of oxidizing substances is a very important question, but one into which it is impossible to enter in a brief note of this kind.

The discussion opened with remarks to the effect that sewage purification in England began with filtration, which was succeeded, respectively, by irrigation and chemical treatment, the latter finally being supplemented with intermittent filtration; now bacteriological methods are in vogue (most of which, the speaker might have added, are only reversions to filtration.—Ed.). Another speaker thought aerobic bacteria were as well able to dispose of the sludge as the anaerobic. Mr. Scott Moncrieff said that in the biological treatment of sewage the process should be divided into stages, each designed to supply food that would bring another class of bacteria into service. In conclusion, the author of the paper said he believed the anaerobic bacteria should be utilized at the outset, though doubtless the aerobic alone could do all the required work.

THE USE OF FILTERED FLOOD WATER.

By Matthew Wilson Hervey, M. Inst. C. E.

The author stated that within quite recent years it was considered most undesirable to take water from a river when in flood for at least ten days or a fortnight after the flood, but now many experts consider that flood water may be taken without restriction, provided that it is afterwards subjected to subsidence and efficient filtration.

It is doubtless desirable, if possible, to allow the first flush of flood-water to pass before taking it into subsidence reservoirs, but it is not absolutely necessary. One flood may be followed comparatively quickly by another, the effect of the first flood having been to cleanse the watershed, and the water of the second is therefore in comparatively good condition.

The author next reviewed the effect of subsidence and filtration on flood waters. He stated that the matter in suspension, in the worst of Thames flood-water, varies from only 1 to 1½ grains per Imperial gallon, or 1.4 to 2.1 parts per 100,000.

He also gave figures showing very low bacterial contents for Thames and Lea flood-waters. In fact, the figures for suspended matters and bacteria cited in the paper were so very low as to render the author's conclusions of comparatively limited application. His conclusions were that "with proper subsidence and efficient filtration flood-water may be taken without restriction, and be delivered to the consumer in thoroughly good condition, both chemically and bacteriologically."

The discussion on this paper confirmed the general conclusions of the author, but gave a broader scope to the subject. Different speakers brought out the facts that with impounding reservoirs on streams it was often necessary to take the water as it came, floods and all; that some flood waters were stained with peat, which stain is reduced by sedimentation when clay or sand is present; and that one of the chief objections to using flood waters is that they speedily clog the filter beds.

DAILY PER CAPITA WATER CONSUMPTION.

By James Watson, M. Inst. C. E.

The gist of this paper was that the legitimate wants and demands of one town are rarely found to coincide with or even approach equality to those of any other town of the same or nearly the same population, and that therefore it is absurd and unfair to lay down a standard rate of water consumption applicable to all communities. The author's reasoning was, in substance, as follows:

> Let me illustrate this by reference to one or two places, and say that Bristol, for instance, with 26 gallons* per head per day, has a full and ample supply, and that Glasgow, with 60 gallons per head per day is extravagant, if not wasteful. Here we have a difference of 230%, yet the cause or causes operating to produce this contrast are not far to seek.
>
> Glasgow supply from Loch Katrine is 1° of hardness, and for ordinary ablutions and detergent purposes the minimum of soap and the maximum of water is used. The non-domestic and trade supplies amounted last year to nearly 20,000,000 gallons per day out of a total consumption of 61,800,000 gallons per day, being 23 gallons per head per day of the whole population supplied; and in addition large unmeasured quantities of water are given free to the other public departments for public health purposes, swimming baths, sewers, flushing, streets and closes (alleys—Ed.), washing. At Bristol the conditions are practically reversed; the water (see discussion) is 22° of hardness, which means much soap and little water to form a lather tolerable to the skin, or having advantageous cleansing properties; again, water is not provided free at Bristol to any of the Corporation departments, and the price of 6d. to 1s. 6d. per thousand gallons charged for non-domestic purposes against 4d. charged in Glasgow tends to limit the trade demand.
>
> Bradford, within the city boundaries, consumes 48 gallons per head per day, 25 gallons of which are used for trade purposes, and this quantity does not include water for public health purposes, streets watering, etc.; but contrasted with Glasgow (which is a water-closet town where water-closets and baths are included in the domestic rate of 6d. per £ on the rental), Bradford, like many other English towns, cannot be well compared.
>
> Bradford, as yet, can hardly be called a water-closet town, having one water-closet to each 16 persons, and one bath to each 38 persons, while in addition to the domestic rate, special charges are made for baths and water-closets.
>
> Comparing Bradford with Bristol, the whole supply per head of Bristol would not do more than to meet the trade and public health wants of Bradford.
>
> The supply to London is about 40 gallons per head per day, Edinburgh 46, Dublin 46, all residential cities; Liverpool 36, Manchester 34, Belfast 42, Dundee 58, and Aberdeen 52, these being commercial and manufacturing centers, and if the factor of preventable waste be eliminated, then it follows that these differences are the results of the legitimate wants, or, at all events, of the free and unrestricted use of the water by the inhabitants.
>
> Waste, preventable and unpreventable, obtains to a greater or lesser degree in connection with every waterworks distribution system, and is the cause and the only cause of the increase to consumption (where proper rules and regulations are in force) which can be dealt with directly by the administrative engineer.
>
> This leads to the conclusion that eliminating waste (taking the term in the restricted sense in which I use it), that all other differences in supply per head per day, between one town and another, are but proper and unalterable measures of the wants of the inhabitants, and a moment's consideration will show that this is so.
>
> In this country the large congested centers of population are fortunately (and I think wisely) not restricted in the full and free use of water for culinary and domestic purposes, and I trust the day is far distant when the incentive to a niggardly use of water (with its accompanying danger to public health and cleanliness) shall be afforded and encouraged by the sale of water by measure for domestic use; therefore, so long as unrestricted constant service is given, the supply per head per day in each town will be measured by the facilities for using water, and by the careful or careless habits of the people in its use.
>
> In addition to constant systematic inspection, attention to the cover-over service mains, the insulation of house service pipes, the strength of pipes, length of lever, diameter of ball, seats of taps, etc., relative to the maximum working pressure, eradication of old and worn fittings within a fixed limit of time, and the careful examination and testing of all new water-fittings at the hands of the water-works authorities, will, if carefully carried out, tend in the future to minimize the one wholly unsatisfactory cause of increase in the water-supply of every town, viz., "waste."

Those participating in the discussion agreed in the main with the author's conclusion that waste and not use was the thing to be fought, but the various speakers gave far more weight to waste than did the author of the paper, attributing to this a large percentage of the variation in consumption between different towns. Thus, at Plymouth a few years ago the supply was about 70 gallons per capita, but by carefully checking waste this was brought down to 50 gallons, including 21 gallons for trade purposes. The population was largely residential. Mr. E. M. Eaton said that in 1869 the water company at Sheffield changed from an intermittent supply (12 hours per day) to a constant service, whereupon the consumption rose from 25 to 50 gallons. The supply failing, the company compelled consumers to put their fittings in order, and within a year after this the consumption came down to 31, and by 1874 to 25 gallons per capita. Mr. Eaton thought the author of the paper had erred in comparing gross quantities (it will be remembered that he talked of eliminating waste, but did not do so in citing figures.—Ed.); to make a fair comparison metered supplies should be deducted. "The water consumer who was not metered had no conscience, and seemed to think the supply came direct from heaven to his taps." Another speaker agreed with Mr. Eaton that the metered supply should be deducted before making comparisons. At Doncaster, still another speaker said, the supply a few years ago was 36 gallons per capita. The town was warned by its engineer that this was excessive, but the authorities could not be moved until a crisis was impending. Rigid inspection reduced the consumption to 22 gallons, although most of the houses had water closets, baths and gardens.

Mr. H. W. Pearson said the hardness of Bristol water should have been given in the paper as 14 to 16°, instead of 22°.

NOTES ON THE RECOVERY OF RESIDUAL PRODUCTS FROM COAL-GAS DURING THE PROCESS OF PURIFICATION.

By William Foulis, M. Inst. C. E.

After introducing his subject with the statement that the valve of by-products once thrown away, is at least $4,500,000 in England, the author proceeded as follows:

> The residual products or impurities which have a commercial value may be briefly described as the liquid hydrocarbons, the nitrogeneous compounds, and perhaps also there may be included the sulphur recovered when oxide of iron is used for purification. In this communication the nitrogeneous compounds only can be referred to. The most important of these is ammonia.
>
> In a paper read in 1896 before the Institution of Gas Engineers the author pointed out that of the total amount of nitrogen in the coal used in gas manufacture, only about 13% was evolved in the form of ammonia, and that more than 50% of the remainder was left in the coke, whilst in other methods of carbonizing, more especially in shale-oil retorts, at least double the above quantity of ammonia per ton is obtained.
>
> In 1897 a paper was read before the Institution of Civil Engineers on the Mond gas-producer, in which it is stated that in this method of gas production there is obtained a quantity of ammonia equivalent to 97 lbs. of sulphate of ammonia, per ton of coal, a quantity four times greater than that obtained in most gasworks. That similar results are to be got in the ordinary process of gas manufacture may be doubtful, but something may be done to recover at least a portion of the ammonia which is at present lost.
>
> The method of heating retorts by gas generated in a central producer and conducted in flues to the retort benches is almost certain to be extensively adopted in the near future. Already practical experiments on a large scale have been made at several works with very encouraging results.
>
> The author's experience leads him to believe that complete success only awaits the overcoming of certain minor difficulties which do not appear very formidable. This method of heating possesses many advantages which it is unnecessary now to refer to, not the least of these advantages is that it would then be possible to recover the nitrogen in the form of ammonia from a large proportion of the coke. A modification of the gas-producer, devised by Dr. Mond, would probably be adopted, and after condensation and scrubbing the gas would be stored in holders for distribution under constant pressure to the retort settings.
>
> In the paper above referred to the author has pointed out that about 0.027% of the nitrogen was evolved as cyanogen. The recovery of this impurity has of late years become of considerable importance to the gas engineer, more especially as the use of cyanide for the recovery of gold from refractory ores has so enormously increased the demand for both cyanide of potassium and cyanide of sodium.

The balance of the paper was devoted to descriptions of different methods of recovering the cyanogen.

LABOR-SAVING APPLIANCES IN GAS WORKS.

By Charles Claude Carpenter.

This and the preceding paper are interesting as indicating to some extent present and future possibilities in the way of low prices for gas. The value of bye-products has been hinted at above, although the paper contained no definite figures. In Mr. Carpenter's paper the saving effected by improved methods was well shown. Thus, transferring coal from Thames' boats to retort or coal storage houses, may be reduced from 4¾ to 2 pence per long ton, by the hand labor saved through the use of self-acting grabs, but the latter require some extra power. The cost of stoking, including capital charges, is 24.8 pence per long ton, against 12.44 for hydraulic stoking, and 9.92 pence for inclined-retort stoking. Besides the saving in labor effected by machinery as against hand-stoking, the output is greater and its quantity superior to the hand-stoked product. As the salable coke weighs more than half as much as the original coal, great savings may be effected by employing the most economical means for handling it. The estimated value of gas as it leaves the retort house was placed in the paper at 20 cts. per 1,000 cu. ft., but with no statement as to whether this included capital charges. Probably the capital charges were included.

---

*The figures in the paper have been converted to U. S. gallons.—Ed.